THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company
MAIN OFFICES:
114 LIBERTY STREET, NEW YORK.
BRANCH OFFICES:
PHILADELPHIA: Real Estate Trust Bldg.
CHICAGO: 1140 Monadnock Block.
CLEVELAND: Cuyahoga Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES:
United States, Canada, Cuba and Mexico....$3.00 a year.
Foreign subscription .... 6.00 a year.
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.
Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD by 10 A. M. Monday of the week of issue. New advertisements can be received up to noon of Wednesday of the week of issue.

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Entered at the New York Post-Office as Second Class mail matter.

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Of this issue of THE ENGINEERING RECORD 12,000 *copies are printed. Total circulation for* 1906 *to date* 204,000 *copies, an average of* 12,750 *copies per week.*

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Indexing Machinery.

The value of accurate records of the essential facts connected with the purchase and operation of each important machine in a modern industrial plant ought to be more widely appreciated. While it is true in most lines of business that an excess of clerical work costs more than it is worth, there are certain facts about the equipment of every machine-using establishment which ought always to be available for immediate use. It should not be necessary to overhaul twenty or thirty sets of specifications in order to determine the trade classification and designation of parts, principal dimensions, rate of production and first cost of a machine, when the occasion for such information arises. It is, of course, something of a problem to know where to stop in working up a file of such data. In one case a manufacturing company established a card catalogue of all its important machine tools, one card being devoted to each tool, which was numbered correspondingly. Only the important data of the tool were placed on the card; essentially the size, maker's name and designation, location in the shop and the tool's capacity. Such an arrangement can readily be extended; the cost of repairs added from time to time, correspondence about spare parts facilitated, later quotations compared with the original cost, and the like. Doubtless all this information could be obtained from scattered sources in the regular contract and correspondence files, but at a considerable cost of time and effort. Information tabulated in this way is of help in taking the annual inventory of a company's assets; in case a fire or other casualty deprives the plant of certain valuable machines, it is a matter of a few moments to order duplicates.

If a machine is found to be capable of forced production the index should record the fact. Changes in the personnel are always occurring in all large companies, and permanent records are necessary in order that each machine shall be pushed to as near its full capacity as possible. The department foreman who succeeds some one else may not realize the exact capabilities of the plant, for it is well known that all machines of the same general characteristics do not work alike. Two locomotives of the same design or two dynamos of the same construction will sometimes perform their work with the most marked difference in behavior. One will steam better than the other, or one will carry overloads with less trouble, and so on. It should not be necessary to rely upon the memory of an employe in keeping close to the maximum intensity of production of the different machines. It is surprising how often one will find companies which do not possess any list of their important equipment. Such data are easy to maintain, and really require very little attention when once brought up to date. A small company can start an index or file of this kind for less than a dollar, and the cost of the matter is almost nominal, even in large plants, in comparison with its permanent live value.

Estimating the Value of Water Power.

The condemnation of water supplies for municipal purposes has become so common that it is desirable to reach some understanding concerning the payments to owners of water powers injured or ruined by the diversion of the natural flow of the streams. The valuation of such a power has been and will continue to be the subject of a great number of law suits and investigations by commissioners appointed for the purpose. How the value of a water privilege of which a mill is deprived shall be determined is a question of considerable importance to both parties, when it is recognized that a single horse-power is in some cases worth no less than $1,000, and even a larger amount. One of the common methods of ascertaining the value of a water power is to estimate the cost of installing a steam plant of sufficient capacity to replace the water power, and the investment required to maintain permanently the expenses of operating the plant, the sum of the two quantities being the amount desired. Although this practice is frequently followed, there are two or three points which parties who desire to obtain a fair valuation should bear in mind. A water power when once developed and the machinery installed is practically self-sustaining; that is, there is no personal element in the care of the motors which controls the expense of the operation. Their efficiency is not dependent upon the care of the attendant, as he has nothing to do save to open and shut the gate. It is not so with a steam plant, for here the machinery requires constant attention, not only in the boiler room but in the engine room, and the operating expenses depend in a large degree upon the efficiency with which the attendants perform their duties. In making estimates, therefore, of the cost of running a steam plant, it would hardly be fair to consider the very best examples and the highest attainable economy of operation under test conditions, for in practice this degree of excellence is rarely obtained, however perfect the design. It seems in every way proper that the conditions of ordinary practice should be those selected, taking into account the limitations of ordinary workmen under the supervision of ordinary managers.

If, for example, an estimate was being made for a triple-expansion engine which, with selected coal, clean boilers, and most careful firing, a tight engine in which the valves are properly set, and all other conditions favorable to economy, may be capable of developing a horse-power on a consumption of 1.4 lb. of coal per hour for a short test, it would hardly be fair to base the fuel expense on a performance of this kind, when in practice under average conditions for a long period of service the consumption of coal might amount to 25 or even 50 per cent. in excess of this quantity. Again, it might be possible for some favored plant to be operated during a number of years of service without expending a dollar for what would legitimately be termed repairs. In making up an estimate of running expenses it would not, for this reason, be proper to charge nothing for repairs, because it frequently happens that through negligence or ignorance some very serious mishap may occur, requiring an enormous expenditure of money compared with the cost of the plant to provide the necessary remedy. In this, as in the matter of fuel expense, it is only fair that a charge should be made covering repairs, which, in ordinary usage, are likely to be needed.

So also with the question of utilizing the exhaust steam of an engine for heating purposes, which, in the case of operation by water power, was supplied by steam direct from the boiler. It is not a question of what might be accomplished under the most perfect arrangement and management, but what is likely to be realized in practice, taking the men who handle steam appliances as they come, with all their whims, ignorance and prejudice. Exhaust steam can be used for many industrial purposes with the same efficiency as live steam, but it is usual to provide a live-steam supply in addition to the exhaust. Where both are at hand, one to be used in case of failure of the other, the operative is sure to avail himself of the live-steam supply whenever he thinks it to be in the least degree necessary, and the result is that in practice the use of exhaust steam for industrial purposes is attended with considerable uncertainty. This is a thing which surely cannot be overlooked in placing a value on water power.

Theoretically the expenses of operation might be capitalized on a basis of the interest obtained from United States bonds, which is recognized as the safest kind of an investment. Practically, however, a board of commissioners would hardly be expected to base its finding on the small percentage of interest which such bonds command. This is proper, because whatever award is made for the damages, the party receiving it would probably not invest the money in Government bonds, but put it into his business, or at least such part of it as remained after installing the steam plant, and obtain therefrom a much higher return for the investment. With this view, if the owner of a water power was carrying on a business which netted 10 per cent. he would be amply recompensed for the damage to his property if the capitalization was based on 10 per cent. He would, at all events, be expected to make a profit of 6 per cent. from his business, and if that was so, a board of commissioners would not think that he ought to recover more than 6 per cent. capitalization.

In many cases the whole supply of water on which the mill depends is condemned, and theoretically the valuation is to be based on these conditions. In practice, however, there are seasons of the year when heavy rains and freshets furnish a surplus of water beyond anything the public authorities can utilize, and during these periods there is a supply for the use of the mill. The owner can avail himself of this and thereby secure more or less reduction in the running expenses of his steam plant. Commissioners should recognize and take into account as far as possible this reduction in making up an award.

The Prevention of Engine Wrecks from Cylinder Water.

Many serious accidents to engines are caused by water finding its way into the cylinder from the steam pipe when the latter is not properly drained, and even from the boilers themselves when these, for any reason, throw it off in the process of priming. Water is also drawn back into the cylinder in the case of condensing engines through failure of the condensing apparatus. These accidents do not occur without good reason, for when the plant is in operation and all its parts are in proper condition, the chance of trouble from this cause is extremely remote. It is the vigilance of the engine-driver and fireman upon which dependence must be placed for the prevention of injury. Instances of this sort have been often mentioned where engines have been broken down as a result of the introduction of water into the cylinder, and, as everyone who has had experience in the matter knows, the effect is liable to be disastrous. It is not merely a few bolts which break or some minor part which becomes deranged, but some vital piece in the structure is the thing which usually gives way, involving the stoppage of the engine and the work which it drives for days or weeks at a time, until the necessary repairs can be effected.

It seems a pity that accidents which from one cause or another are so liable to occur and which are attended with such important consequences, cannot in some way be made less disastrous. With so much at stake designers of engines might bring about some system which should lessen, if not wholly overcome, the evil results following the introduction of water into the cylinder. The engineer maintains that he cannot supply in his design the brains and vigilance which the engine-driver lacks. He claims that it is one of the exigencies attending the generation of power that a charge of water may get into the cylinder, and when that happens the only thing to do is to accept the consequences, however serious they may be. This, however, is not what the power-plant purchaser requires from engineering. He states the conditions, and what he desires of the engineer is that the iron and brass shall be so put together that the conditions will be met, one of the most important of which is that his plant shall be kept running and turning out regularly the allotted quantity of production.

Considerable improvement has been made of late years, it is true, with a view to providing against injuries of this kind. Cylinders are fitted with relief valves, set at a point slightly above the highest working pressure, and made of considerable size so as to provide a means for the escape of water if it should accumulate in excessive quantity. They are applied to the sides of the cylinder, one at each end, and with this location it will be seen that they can be made of only limited size. Experience has shown that this plan does not secure a sufficient opening to discharge the large volume which must be taken care of if the water comes over at all.

In the case of single-acting engines, the injury produced by accidental accumulations of water can be greatly lessened by making the cylinder head of such form that when a dangerous pressure is brought to bear upon it, the breaking strength is exceeded, and the central portion of the plate gives way, and allows the water to discharge through an opening, nearly, if not quite, the full size of the bore of the cylinder. Such an arrangement is impracticable on the ordinary double-acting engine, owing to the attachment of the framework of the engine to the opposite end of the cylinder. The same idea, however, might be carried out by providing a secondary cover of a diameter considerably less than that of the cylinder bore, the cover being designed so as to give way by breakage when a dangerous pressure is reached and thus provide a relief opening of much greater size than could be had by the common practice. There may be other methods of accomplishing the same end, but it must be admitted that some better means of meeting emergencies in the running of engines due to water in the cylinder should be provided. There is something incongruous in designing some detail of a cylinder so weak as to invite breakage when the pressure reaches a certain limit, but if this serves as a safety valve and prevents the wrecking of the main structure, it is certainly a wise provision.

The Study of Details.

In a letter published in The Engineering Record a number of years ago, Mr. Rudolph Hering called attention to the importance of notes concerning minor details in broadening the field of engineering information. He pointed out that the object of building sewers is to have them do a certain kind of work, and reports on how successfully this work is being done by them, on the methods found most satisfactory in maintaining them and on their actual cost, furnish the data on which alone improvements in the design of sewers may be based. In other words, progress in general design is dependent on definite information regarding many details. An engineer whose work covers a considerable range of subjects must have at his command a large amount of detailed information similar in character to that referred to by Mr. Hering in the case of sewerage undertakings, and the problem of securing such information is an important one. How it is solved depends largely on the temperament of the head of the office.

It is doubtful if there will be any serious objection to the statement that the men most prominent as engineers may be grouped into two classes. The first embraces the small number of men who succeed because of their keen judgment in reading human nature, rather than by their personal knowledge of the details of engineering. They would succeed in any professional or business career in which they do not have to execute details themselves. Their judgment is such that they detect by intuition the sham expert, the conceited specialist and the self-assertive ignoramus. They have the keen insight into human nature which enables them to pick their assistants skilfully, and to obtain from each that which he can best do. The other class of successful engineers is made up of the men who know the fundamental facts of their specialty as they know their alphabet. They have themselves performed the details of every branch of it. They have watched others doing the same work, know how much the average assistant can accomplish, and have marked down the men who do more than the average. They have thus learned by experience what the first class appreciates by intuition. They have a knowledge of the men who will be useful to them, and this enables them to stand on an equal footing with the first class when they are called upon to undertake those large works where all that the head of an engineering corps can do is to plan on a very broad scale from information furnished by others.

All this is merely another way of saying that engineering, as it is practiced to-day, is developing along the same lines as commercial pursuits, by securing the co-operation of men expert in different details. This is no reflection on the professional nature of engineering, but, on the other hand, one of its great attractions. There is a place for the man who desires to specialize, room for the man whose inclination is toward executive positions and plenty of opportunities for those who like the field work of construction. These considerations of engineering show why it is so attractive in spite of its present comparatively low remuneration, and also indicate the path which most young men must follow to achieve ultimate success.

No one who watches the rapid growth of modern engineering can fail to notice that it is widening its field of certainty, diminishing the factors of safety it has to use, very largely because a great number of keen, educated men are filling up all the little gaps. Where theory breaks down, we now have experimental data to guide us. Where we formerly built massively because prior experience showed such construction to be strong, we now build only so heavily as theory and a knowledge of the strength of materials warrants. Possibly our structures may not resist the teeth of time during quite so many centuries as some of the works of Greece and Rome, but the people whose money pays for them may not feel called upon to build for eternity. There is such a thing as putting too much as well as too little money into structures, and it may well be placed to the credit of the engineer that he has developed the special knowledge which must be the basis for a decision when such a question is to be settled. This special knowledge is essentially a matter of detail. If any young man thinks that the active head of great undertakings is not able to plan details he is mistaken. The head of a group of famous manufacturing companies spends many nights every month in his private shop elaborating details. Every Saturday there is a meeting of the heads of all departments of one of the greatest industrial corporations in the country, so that every man may be informed of any new idea in any other department. Everywhere among truly successful enterprises it is now taught by precept and example that the little matters, easily forgotten or laid aside, are the sources of valuable information and the subjects in which study will very likely produce economy. Economy is the final test to-day of the engineer. Office buildings are full of men able to design works that will answer a given purpose. A diligent study of a handbook of formulas and some visits to supply men will give the information necessary to build a work which will fulfill its object. But competition will not make it answer long. The business rival will engage men who know all the details of the subject, who can write their own handbooks and design their own supplies if necessary; and by their superior grade of information will enable their client to achieve first rank, provided his business methods are as good as his engineering methods.

Notes and Comments.

A 150-ft. Standpipe is now in course of erection in Mt. Oliver borough, near Pittsburg. It will be 25 ft. in diameter and will replace a pair of tanks about 30 ft. high, which have previously been employed. This standpipe will be a part of the works of the South Pittsburg Water Co., and will serve to increase the pressure in the mains extending from Homestead to Bridgeville. Owing to its elevated position water stored in the lower portions is serviceable and for this reason the selection of a standpipe rather than a water-tower was entirely justifiable. The structure is one of the highest in the country.

An Inadequate Culvert on the Pennsylvania R. R. resulted in flooding some land, for which the trial jury awarded damages to the owner. The company appealed from a part of the award on the ground that the landowner should not receive compensation for grain stacked on land never before covered by water, although the culvert had been constructed thirteen years. The New Jersey Court of Errors and Appeals has decided against this claim, 62 Atl. Rep. 702. The railroad should have ascertained all the conditions governing the work and then given the culvert a capacity ample for any volume of water which could be reasonably anticipated. No such duty devolved on the landowner, and because he considered a knoll safe from backwater was no proof that the company was warranted in reaching the same conclusion, the court rules.

Assistant Professors' Salaries in engineering schools ought to be increased, for it is not right to ask the grade of men who should be employed in responsible educational places to serve for the small sums now offered. In a recent list of vacant positions of this nature, the salaries offered for assistant professors were only $800 to $1,600, not enough to induce competent men to give up regular engineering work except at a pecuniary sacrifice. It is true that such places afford an opportunity for earning something during vacations, but as assistant professors have to carry the hard work of instruction and much of its responsibility they ought to be paid proportionately. A man holding a full professorship is usually given opportunities for earning large additions to his salary, but this is not the case with assistant professors and instructors, save in a few colleges. So much of the value of technical education depends on the ability and character of the men holding the less important places, that the financial inducements to accept such places should be ample to attract men of high grade and keep them after they have been engaged.

The Hydraulic Laboratories at the University of Wisconsin, described elsewhere in this issue, and at the Worcester Polytechnic Institute, described a few weeks ago, are examples of educational and research facilities which it is gratifying to see increase. The laboratory at Cornell University has yielded so much information of the highest technical importance that there can be no question about the value of the experimental work that can be done in such places. The data that have been furnished from the Cornell laboratory concerning the discharge over dams and weirs are now accepted as authoritative wherever they have been studied. The work at Worcester will probably be mainly along the line of hydraulic power research, while the investigations of centrifugal pumps which are already under way at Madison will undoubtedly throw much-needed light on some of the complicated relations which must be determined experimentally before machinery of this type will receive the public approval it merits.

Mosquito Extermination bids fair to receive far more attention this year than ever before. Formerly there was a feeling that the sprinkling of pools with kerosene and the ditching of swamps so as to prevent the collection of stagnant water were hardly more than fads, and while they were innocent amusements for a few enthusiasts the best exterminator was local hand-action, delivered sharply and promptly, coupled with general treatment by smudges. We now know, however, that the time to get rid of the little nuisances is while they are in their immature state. If care is taken to prevent the collection of water in stagnant pools of large or small size, and kerosene is sprinkled over the surface of suspicious places, the development of the insects will be checked. In some towns where they were formerly a serious pest in summer, they have been practically exterminated by these methods, for they do *not* travel long distances. If the board of health and city engineer in any place where mosquitoes have caused trouble in previous years are given the means for carrying out simple remedies, and if householders will see that no water is allowed to stand about their premises in pools, barrels or old cans, a great improvement can be effected. Announcements of such action have been received from a number of places, although the season of the mosquito's activity has not yet arrived, and all places previously afflicted with the insect will do well to adopt the system.

The Public Improvements in New Orleans will cost a much larger sum than has been voted for them, and the Sewerage and Water Board of the city has accordingly prepared a plan for raising the necessary additional funds. The first bond issue authorized was for $12,000,000 and it is estimated that $8,000,000 more must be raised. This is a large sum for a place of about 300,000 population, but the conditions which render it necessary are unusual. The drainage problem, which was first undertaken, is a very difficult one, and without an increase in the funds now available one district cannot be drained at all, except by the old inadequate provisions, and a main drainage canal cannot be constructed, although it was the leading feature of the original project. Moreover, the drainage of the city is now discharged into Lake Pontchartrain, something the advisory engineering board has strongly discouraged. The peculiar geographical and climatic conditions at the city make the completion of the drainage works very desirable for the health and comfort of the people, and for this reason the proposition to spend $6,000,000 in finishing them is one which is commendable. Deducting this sum from the total proposed bond issue leaves $2,000,000 for the completion of the sewerage and water works. This bond issue must be authorized by the legislature and approved by popular vote, but it is such a wise expenditure of money and involves such a small increase in the tax rate that there seems to be little chance of adverse action. In fact the most serious obstacle may be found to lie in the disposition of the bonds, as the whims of investors are hard to foresee.

The San Francisco Catastrophe has not been reported in any detail up to the time this part of the paper goes to press, and accordingly it is only possible to point out that steel-cage construction has again vindicated its claims for structural superiority. While buildings of the ordinary commercial and warehouse type were shaken down like houses of cards by Wednesday's earthquakes, the more imposing buildings of the steel-cage type resisted the swaying of the earth and were injured by fire alone, except in some of their more fragile portions. The tremendous shaking the unfortunate city received not only opened the gas mains and wrenched boiler plants and smaller furnaces so that fire sprang up in many places, but it also wrecked the system of water mains in those districts where water was most needed to check conflagrations. The fires were fought by dynamiting small buildings, but this is a feeble method and the results were naturally poor. The important lesson of the disaster is the necessity of better construction of buildings in a city so subject to earth tremors as San Francisco. Small vibrations occur there frequently and indicate the probability of occasional greater disturbances. The Japanese have recognized this fact and have been constructing their more important buildings with steel-cage frames. The palace of the Crown Prince, which was described in this journal a few years ago, is an excellent example of a comparatively low building designed with special reference to high resistance to earthquakes. It is out of the question, of course, for residences and small commercial structures to be built with steel frames, but it is equally incorrect to rely on ordinary methods of framing in a locality where the joists of a floor are likely to be shaken out of the wall recesses where they rest. At this writing, the greatest loss of life seems to have occurred through the collapse of floors in this manner. Until more complete information is available, however, it is futile to attempt any elaborate discussion of the technical details of this great calamity.

The Panama Canal Situation is one that cannot be viewed with any degree of satisfaction at present, because it is arousing unmerited criticism among people and papers of high standing in the country. It is inevitable that a great deal of unfavorable comment which has no basis in fact will be poured out on the Isthmian Canal Commission and its staff. This is to be expected in all public enterprises. On the other hand, unwarranted criticism from reputable sources, such as is now heard, indicates that the many shifts and changes made in the administration of the undertaking have been misinterpreted. For example, the New York "Eevening Post" charges in a recent article that previous commissions have shown incompetency and that now charged with the direction of the work is nearly as far from a definite basis of action as it ever was. Such assertions are entirely incorrect, and it is important to understand why they are incorrect. Previous commissions were not incompetent, but all carried forward the work intrusted to them in an excellent manner. They were esesntially commissions of investigation, organized to conduct studies on which a plan of action could be formulated. The last commission of which Admiral Walker was the chairman was forced by public sentiment, or some other kind of pressure, to go ahead with some of its work unseasonably, but it progressed far enough to recommend a sea-level canal before it resigned. Since the present members of the commission have held office their hands have been tied by the necessity of waiting for the Board of Advisory Engineers and then for Congress to fix a type of canal. Congress has not yet taken any action and it is difficult to see what the Commission can do under the circumstances that it is not doing. Had the old commission been retained work would probably have been much farther along. There is nothing in the present condition, however, which warrants the public in feeling the slightest uneasiness. There is a deep difference of opinion among engineers concerning the type of canal to be built, but this difference does not mean that either type is impracticable. It is the same kind of a difference of opinion, save in degree, which makes horse races possible and enables many automobile manufacturers to carry on business. What satisfies one man may be unsatisfactory to another, and yet be intrinsically good.

LEVEE AND DRAINAGE WORKS AT MEMPHIS.

With a Pumping Plant Having Several Unusual Features.

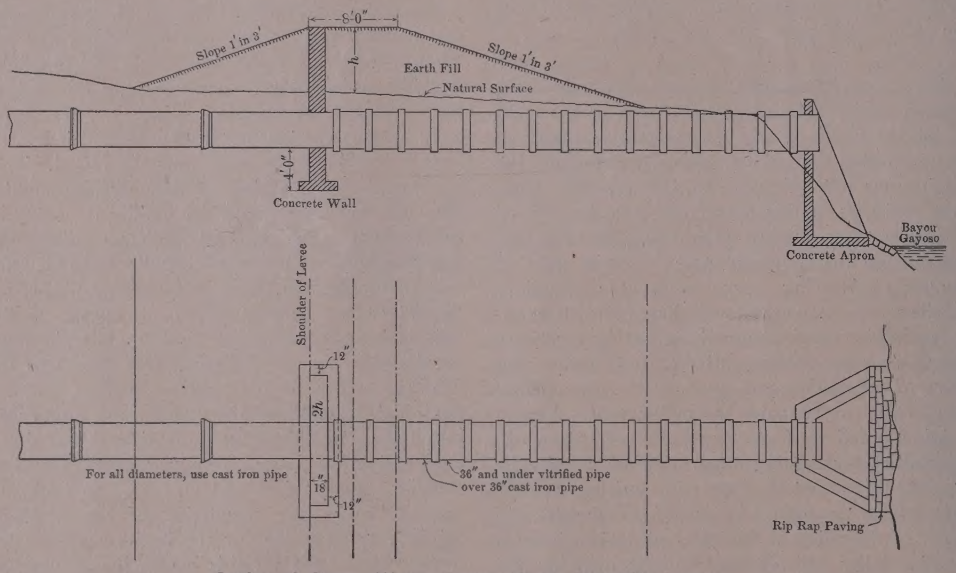
A system of levees has recently been completed in Memphis, Tenn., which will protect an area of approximately 110 acres near the central business district of the city from back water during floods in the Mississippi River. This central business district is built north and south along a high bluff paralleling the east bank of the river. The Wolf River, a stream which ordinarily carries a comparatively small volume of water, has its mouth in the Mississippi River a short distance north of the district, and extends nearly parallel to the north and south streets of the city for some distance to the north. About a mile above the mouth of this stream is the mouth of a small tributary to it, called Bayou Gayoso. This tributary extends back inland for about half a mile and then turns to the southeast, roughly following along the rear of the business district.

Bordering along the banks of the Bayou Gayoso is about 130 acres of land that is subject to overflow by backwater from the Mississippi River, unless protected. The extent of these overflows and the frequency with which they occur have been greatly increased during the last few years by the construction of levees parallel to the Mississippi River along the St. Francis Basin. This basin is a broad expanse of land most of which is only slightly above mean water level in the river. It starts just below the junction of the Ohio and Mississippi rivers, near Cairo, Ill., and extends for about 215 miles to the south along the west bank of the latter river. The levees have been constructed along the bank of the river to protect this basin from floods. The basin formerly produced a very marked equalizing effect on the great volume of water which is carried by the river during floods, so that since the construction of the levees which confine the flow of the river to its channel the flood levels between Cairo and Memphis have been raised very materially.

The area in Memphis which is protected from the floods by the new levees along Bayou Gayoso is thickly populated and is all within reasonable distance of the business district of the city. Although this area has never been developed in proportion to the development of the adjoining portions of the city, owing to the liability of flooding, the damage done in it by an overflow is considerable. It is to be questioned whether the city would have been justified, however, in making the expenditure necessary to construct works to avoid the repetition of such overflows on the basis of simply preventing the damage done to property. The chief factor in building the levees has really been to prevent the unsanitary conditions following an overflow of the district. The sewerage system of Memphis is designed to carry the domestic flow only, the storm-water flow being carried to natural water channels in gutters along the streets. One of the principal outfall sewers of the city crosses the bayou and the protected area, about one mile from its outlet in Wolf River. When the stage of water in the river reached an elevation 2.5 ft. below the highest flood level which has thus far occurred, the head which sewage from the higher parts of town had to overcome to reach an outlet became so great that the covers of the sewer manholes were lifted off by the head on the sewage in the outfall. The sewage then flowed out of the manholes and along the streets until it reached the partially stagnant backwater of the bayou, or the water over the low area along the latter. Floods generally occur in the spring or early summer, so that the extremely unsanitary conditions produced by this backing up of the sewers were aggravated by the summer heat after the floods had receded.

Several plans for protection works were proposed. The plan adopted was to build a levee up each side of the bayou, starting at the mouth of the latter and continuing something over 1¼ miles until ground above the highest flood level is reached, the crest of the levees being 1.5 ft. above the maximum known flood; a pumping station has also been built near the lower end of these levees to raise and discharge into the bayou the storm water falling back of the levees in that part of the basin lower than the high water plane of the river. The storm water from the higher districts back of the low areas on each side of the bayou between the mouth of the latter and the upper end of the levees is intercepted above the maximum flood plane and discharged into the bayou through a system of cast-iron pipes.

In addition to the protection afforded to the low area by the levees, the Louisville & Nashville Ry., running east and west and Main St., running north and south, across the area, are on embankments entirely above the high-water plane. These embankments, together with the levees, divide the district subject to overflow in several distinct pockets, or compartments, so that a single break in the levees could flood one of these compartments only. The inlets to the sewers in the compartment overflowed could be welled up with sand bags and the levee repaired after the pressure from the overflow had been relieved. The sewer inlets would then be opened and the water pumped out of the flooded district.



Outlet of Storm Water Sewer, North Memphis Levee.

A watershed of about 400 acres is tributary to the bayou between the mouth of the latter and the upper end of the levees along each side of it. Of this area, 250 acres are above the highest elevation, 226.83 ft. above the water level in the Gulf of Mexico, a flood will probably ever reach at Memphis before levees along the Mississippi River are broken or over-topped. An area of about 225 acres is drained by the high-level storm water sewers and one of 126.3 acres by the low-level storm water sewers. The levees protect an area of approximately 100 acres from overflow, 35 acres being left unprotected between them; but of this latter area 12.5 acres are between the bayou banks and could not be protected by any system of works.

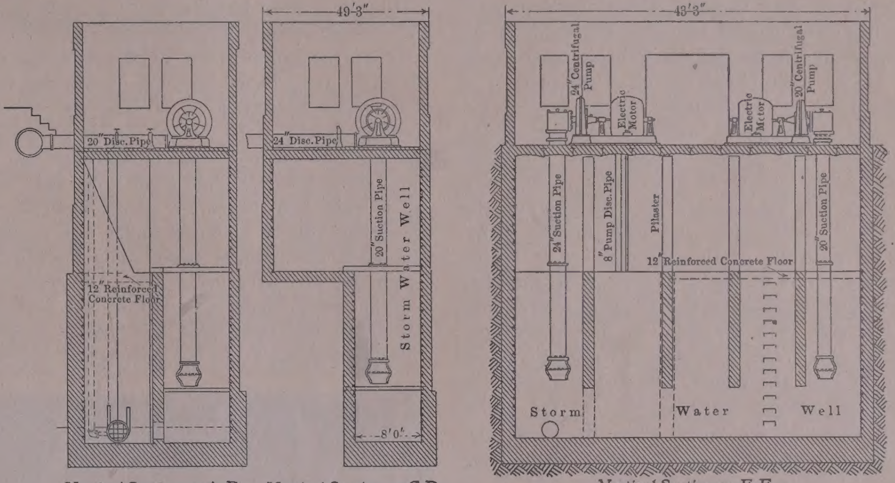
The elevation to which the levees have been built may at intervals of many years be below the highest stages of water in the river. There is also an area of more than 6,000 acres of ground above the limits of the levees, most of which has paved streets through it and is closely built up, from which the storm water run-off drains to the bayou. The rainfall in Memphis is generally heavy at the season of floods in the river, the maximum rate observed over an extended period being 5 in. in 3 hr. In order to secure sufficient hydraulic gradient in the bayou when the water is backed up in it to carry this storm water flow to the river the levees may have to be higher than at present built toward the upper end. Either of these conditions which would result in over-topping the levees are extreme, and in designing the works it was considered that the levees could more economically be raised with 10,000 to 15,000 bags of sand, at 10 cents a bag in place, at very rare intervals to overcome them, than to make the increased expenditure necessary to afford absolute protection to the low areas under all conditions of floods. Furthermore, the eventual plan is to raise the grade of the low area above the maximum flood level, starting with the raise in the grade of some of the streets, which has already been made.

Levees.—The typical cross section of the levees is an earth embankment 8 ft. wide on top, with 1 on 3 slopes on each face. Owing to the exceedingly limited right-of-way available, due to the congested manner in which the area to be protected was built up, this cross-section had to be changed to suit local conditions. A considerable portion of the levees on one side of the stream were built by raising the grades of some of the streets and alleys parallel to or crossing the bayou in the low area. At other points where buildings stood close to the bank of the bayou reinforced-concrete retaining walls were built to confine the stream to its channel.

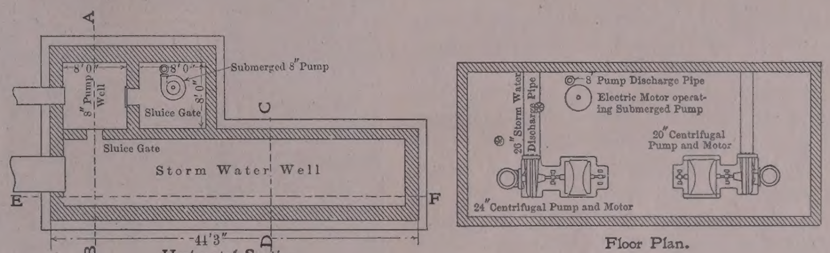
The earth embankments were, in general, made of material obtained by lowering the grades of streets in the adjoining high-level districts. The ground to be occupied by the embankments was in many places covered with trees, stumps, old logs and various kinds of rubbish and perishable matter. All the trees, stumps and larger roots were grubbed out and removed. All buried logs, decayed roots, cinders and other perishable matter was removed to a point at least 3 ft. outside of each toe of the levee embankment. The surface thus cleaned was then broken to a depth of 6 in. with a plow. A muck ditch of dimensions considered great enough to cut off undermining of the embankment in each case was then dug along the site of the embankment. This ditch was filled with clayey material, thoroughly puddled as it was placed. The embankments proper were built with teams and scrapers, or wagons. When the embankments had been brought to full heights they were dressed and planted with Bermuda grass, except those along streets and alleys.

In five or six places along the bank of the bayou, buildings were so close to the latter that in order to build a safe levee the toe of the embankment would have to have been extended across the existing channel of the stream, or expensive right-of-way purchased. Reinforced-concrete retaining walls, 20 to 30 ft. high, were, therefore, built instead of the usual embankment. The typical wall is 15 in. wide just under the coping, and has a vertical front face and a batter on the back face of 1 in. to the foot. The base of the front face of the wall is 18 in. back from the toe of a flat reinforced-concrete slab footing on which the wall stands. This footing is 2 ft. thick and has a width back of the front face of the wall of 0.5 the height of the latter. The concrete in the wall was made of 1 part cement, 3 parts sand and 6 parts broken stone, reinforced with light steel railroad rails. The cost of the largest of these walls, including excavations and back filling, was approximately $24 a linear foot, making the total cost of 200 ft. of the wall $4,800. A gravity section retaining wall of the same height and length, it is estimated, would have cost $15,000 and would have been difficult to build, owing to the lack of suitable foundations. The estimated cost of an earth embankment in the same place, exclusive of the right-of-way, was $4,000.

Another portion of the levee near the mouth of the bayou was built with considerable difficulty. An earth embankment of the typical section, which had been built in the usual manner, slid bodily toward the channel of the stream for a length of nearly 60 ft. After repeated futile attempts had been made to restore the embankment and a row of piles driven along the toe of it had been pushed entirely out of line, a specially designed concrete retaining wall was built. The natural foundation for a length of about 60 ft. across the site of the embankment was unconfined quicksand so the wall could not be built on it. A heavy concrete abutment was therefore built on each side of the quicksand pocket and a reinforced-concrete beam, 2 ft. thick and 10 ft. high built across the latter between the abutments, the top of the beam being at the level of the top of the levees. After the beam had been built a fill was made in front and back of it and around its abutments. A projection was built on the back face of the beam about 3 ft. above the base of the latter. After the fill back of the beam had been carried up to this projection a layer of boards, covered with tarpaper, was placed horizontally with one end on the projection on the beam, the other end on the natural ground, to prevent the fill back of the beam from passing under the latter. The beam is designed to carry its own weight and also to overcome the thrust of the water against its front face, or of water and earth against its back face, the fill in front of it being expected to slide more or less when the water comes up. The fill back of it has so far held perfectly since the beam was built, and it is believed no difficulty will be experienced from slides during a flood.

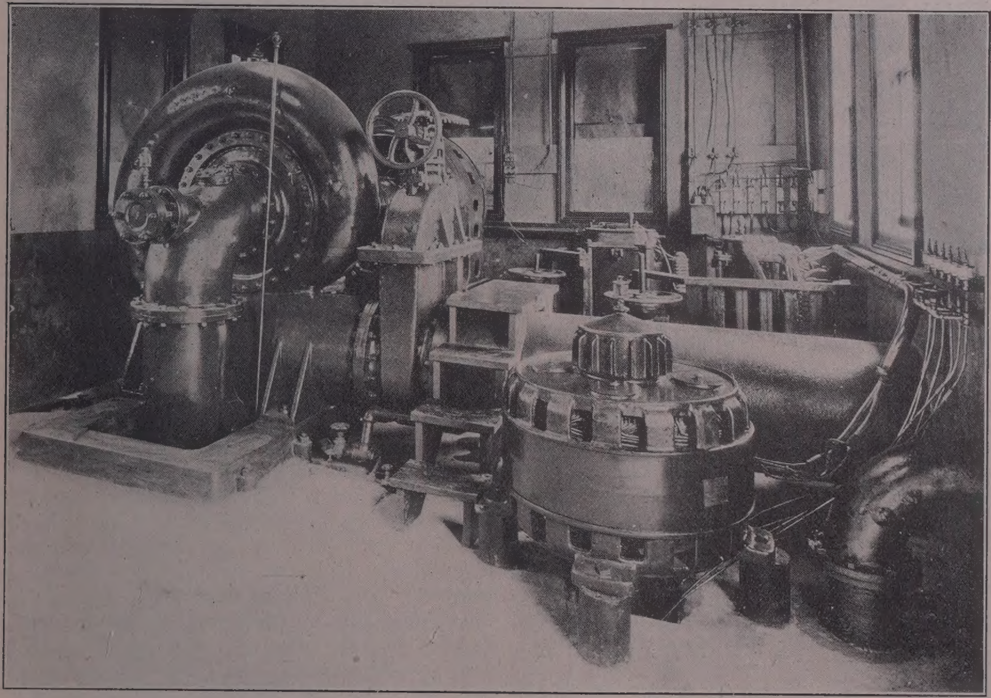


Vertical Section on A-B. Vertical Section on C-D. Vertical Section on E.F.


A
B
C
D
E
F
8'0"
8" Pump Well
8'0"
8'0"
Submerged 8" Pump
Sluice Gate
Sluice Gate
Storm Water Well
44'3"
8" Pump Discharge Pipe
Electric Motor operating Submerged Pump
20" Storm Water Discharge Pipe
20" Centrifugal Pump and Motor
24" Centrifugal Pump and Motor

Horizontal Section. Floor Plan.

Arrangement of Pumping Station for Storm Water.



Motor for 8-Inch Submerged Pump and 20-Inch Pump and Motor.

High-Level Sewers.—The higher ground back of the low areas on both sides of the bayou is naturally divided in several districts, each draining to the bayou. Several of these natural drainage districts have been divided into smaller districts by the grading of streets and railroad embankments. In order to divert directly into the bayou as much as possible of the storm-water flow tributary to it within the limits of the levees and thus avoid pumping, each of the drainage districts has been provided with an outfall sewer laid across the low areas immediately back of the levees.

These outfalls will be under a head of several feet when the water is backed up in the bayou by floods in the river. Since a break in one of them would be as serious as a crevasse in the levees, they have nearly all been built of cast-iron water pipe with lead joints. A concrete collar wall was built around each outfall at the point where it passed through the levee along the bayou, the wall being along the back shoulder of the embankment and parallel to it. Each of these walls has its top flush with the top of the bank, is 18 in. thick and has a length equal to twice the height of the portion of the wall above the natural ground surface. Each wall has a footing 3.5 ft. wide, the bottom of which is 4 ft. below the invert of the pipe. Between this concrete collar wall and the end of the outfall, vitrified clay sewer pipe was used, or a brick sewer built. The banks of the bayou at the ends of the outfalls are protected from wash by the flow from the latter by concrete aprons, or by manholes, depending on the location.

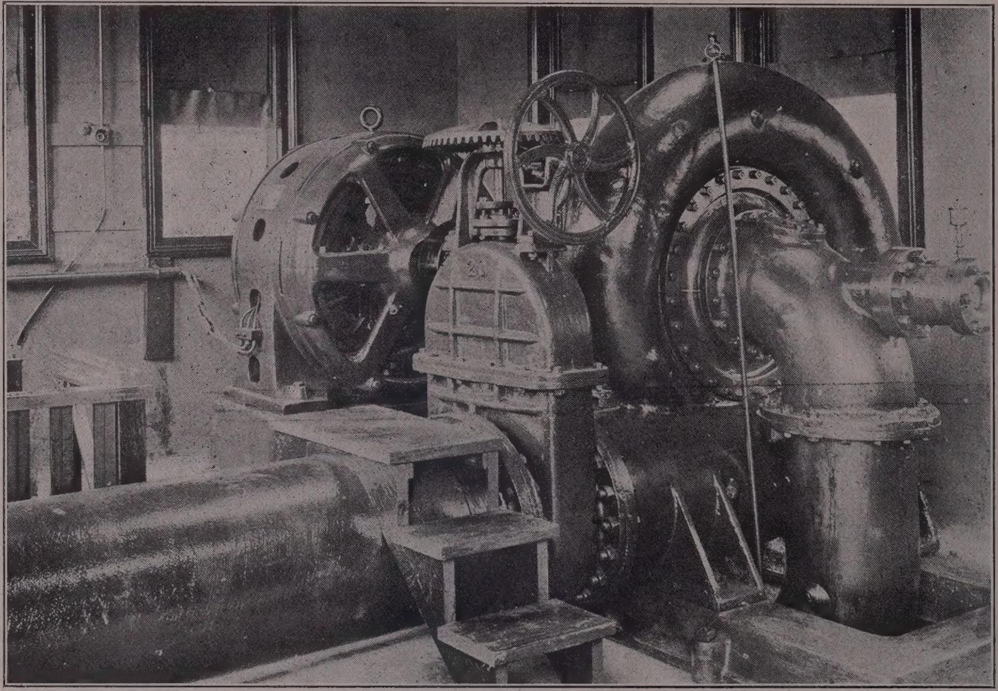
Low-Level Sewers.—The storm water run-off from all of the areas back of the levees and below Elevation 110 has to be carried to the pumping station, and during floods in the river elevated into the bayou by pumps in the station. A system of collecting sewers has been built through the low-level area on each side of the bayou. The system on the left hand side of the bayou is much the larger, having approximately

13,000 ft. of 8 to 36-in. cast-iron and vitrified-clay pipe, as compared with 8,300 ft. of 8 to 36-in. cast-iron and vitrified-clay pipe and brick sewers in the system on the opposite side. These systems both have concrete catch basins generally built in the gutters at street intersections in the low areas to intercept the storm water.

The 36-in. main sewer of the system on the left-hand bank had to be laid under the bayou toward the lower end of the levees in order to reach the pumping station. About a quarter of a mile from this bayou crossing the main 36-in. storm sewer on the left-hand bank crosses the line of the 48-in. brick sewer which carries a large portion of the domestic sewage flow of the city, and from which overflows during floods have given much trouble in the past. The sewage has a depth of 1.1 ft. in the 48-in. sewer during a normal flow, and when the level of the river at its outlet does not back up the water in it. The invert of the 36-in. sewer is 1.2 ft. above the invert of the 48-in. sewer, so that under normal conditions the smaller sewer does not interfere with the flow in the larger one. During storms the flow from the 36-in. storm sewer divides, the greater part of it going out through the 48-in. sewer as long as the outlet of the latter in the river, which is below low water, is not too deeply submerged. About 1,500 ft. toward the river from the intersection of 36 and 48-in. sewers, a gate valve has been placed in the latter and will be closed during high water in the river in order to prevent back water passing up into the sewer beyond the gate. Just above this gate valve a 16-in. cast-iron main leading to the pumping station has been connected with the 48-in. sewer. This 16-in. main will divert the normal flow from the 48-in. sewer to the pumping station during floods, and will also assist the 36-in. sewer leading to the station in carrying the flow from the 48-in. sewer during storms. The 16-in. cast-iron main is about 1,500 ft. long, and intercepts the 48-in. sewer at a point where the invert of the latter is about 21 ft. below the ground surface. In order to lay the 16-in. sewer so that a gravity flow would take place through it from the 48-in. sewer to the pumping station a deep cut, nearly 1,500 ft. long through bad soil, would have to have been made. In order to avoid this cut the 16-in. sewer has been laid at an average depth of 4 ft., and a siphon built at the junction between it and the 48-in. sewer to raise the sewage from the latter to it. This siphon has to be primed whenever it is put in operation. The priming is done by an air-and-water chamber placed in a manhole built in the ground near the siphon. This chamber consists of two lengths of 24-in. water pipe joined together and sealed at the ends. It is connected with the distribution mains of the city water works and also with the 16-in. main by pipe controlled by hand-operated gate valves. An air blow-off, controlled by a hand-operated gate valve, is also provided and permits the air to be drawn out of the chamber when the latter is being filled, if necessary. Usually, however, the air will be compressed in the chamber by the incoming water and will later force the water into the siphon.

The priming chamber is thus operated entirely by hand, which is considered much more safe than any automatic arrangement that could be devised. The lower end of the 16-in. siphon is in a sump 3 or 4 ft. deep in the 48-in. sewer, the total lift required in the siphon being 14 ft. The priming of the siphon has to be repeated every 6 to 8 hr., owing to the large amount of gas carried by the sewage and to the leakage which unavoidably occurs through the joints of the 16-in. pipe leading to the pumping station. Since the siphon will be required to operate under the most adverse flood conditions, and then only for brief periods, it is believed to be the most feasible arrangement that could have been adopted. Furthermore, the air-and-water chamber can be operated by the attendant in charge of the pumping station, which is about 1,500 ft. from the siphon.

Pumping Station.—The pumping station was placed on the right-hand bank of the bayou so that a favorable site on that side, which was available at a very reasonable cost, could be utilized. The station building is 17 x 40 ft. in plan and is built entirely of reinforced concrete. The floor of the pump room of the building is at Elevation 104.5, which is 5.5 ft. below the maximum flood level that it is believed will ever occur; but the walls of the building are tight and the sills of the window openings are just above the maximum flood level. The door opening is only 5 ft. below the street level, so that the pumps can be operated under any condition. The 36-in. storm-water sewer from the low-level system on the left-hand side of the bayou and a 30-in. storm-water sewer form the low-level system on the right-hand bank enter a storm-water suction well 34.5 ft. deep below the pump room floor, under the rear half of the building. The 16-in. cast-iron relief from the 48-in. sewer discharges into a well 8 x 8 ft. in plan in front of the storm-water well and under one end of the pump room.



24-Inch Centrifugal Pump Driven by Direct Connected Induction Motor.

The pumping equipment in the station has a normal capacity of 40,000,000 gal. per 24 hr. It consists of three centrifugal pumps, built by R. D. Wood & Co., which are direct connected to 3-phase Westinghouse induction motors. Two of the pumps, one a 20-in. and the other a 24-in., are placed on the floor of the pump room. They elevate the flow which reaches the storm-water well and discharge it into the bayou through pipes laid through the levee. The 20-in. pump is direct connected to a 150-h.-p., 3-phase induction motor, the unit operating at 495 r.p.m. The 24-in. pump is direct connected to a 175-h.-p., 3-phase induction motor, the unit running at 435 r.p.m. The third pump is an 8-in. horizontal one, which is placed in the bottom of an 8x8-ft. chamber adjoining the well into which the 16-in. cast-iron relief main from the 48-in sewer discharges. This pump is direct connected through a vertical shaft to a 50-h.-p., 3-phase induction motor on the floor of the pump room. Power to operate the motors is purchased from the company operating the electric lighting system of Memphis.

The capacity of the pumping station is equal to any flow that can reach it, based on the rainfall records available. The motors driving the large storm-water pumps each have a rated capacity 30 per cent. in excess of the capacity required to drive the pumps under normal conditions. The great increase in the quantity of water delivered by a centrifugal pump as its suction lift is reduced, resulting in a corresponding increase in the power required to drive the pump, led to the adoption of the excessive size of motors, so that the capacity of the station can be greatly increased as the water rises in the storm-water pump well. Adjoining the pumping station is a natural depression back of the levee which has been enlarged until it has a storage capacity of about 4,000,000 gal. An overflow from the suction well is placed 20 ft. below the pumps so that any flow in excess of the capacity of the pumps may be diverted into this depression and drawn from the latter as the pumps overcome the quantity of flow. In case one pump is disabled the excess flow can also be turned into this pit.

The 8-in. pump pit is separated from the well into which the 16-in. relief sewer discharges, by a concrete wall, the pit and the well being connected by an opening through this wall which is controlled by a sluice gate operated from the floor of the pump room. The suction well of the storm-water pumps and the well into which the 16-in. main discharges are connected through an opening in the bottom of a concrete wall which separates them. This opening is also controlled by a sluice gate operated from the pump-room floor. The 8-in. pump is located so it can be used as a bilge pump, which will empty the pit in which it operates, or either of the receiving wells, if necessary.

The sides and bottom of the pumping station are practically one solid piece of concrete. The extreme height of the structure to the line of the roof is 52 ft. One side of the building is against the street line, and the fill on that side is within about 9 ft. of the roof. On the opposite side it is only within 30 ft. of the roof, leaving a large unbalanced over-turning moment. The structure is perfectly stable, however, even when empty; but in order to distribute the thrust against it from the fill of the street, the wall on that side was heavily buttressed against a partial mezzanine floor between the bottom of the well and the pump room.

Construction.—No unusual difficulties were encountered in any of the construction work, further than those already explained. The crossing of the bayou with the 16-in. cast-iron and the 36-in. vitrified pipes was made at the same point by diverting half the flow of the stream at a time with cofferdams. Several bridges over the bayou had to be raised, or reconstructed. The highway bridges have been rebuilt of reinforced concrete. One 150-ft. steel-truss span, carrying the traffic of a highway and two street car tracks, was raised 4.7 ft. with jack screws without interrupting traffic.

Cost.—The detail contract prices for work on the high and low-level storm-water sewerage systems are given in the accompanying table. The contract price for brick manholes was $45 each, for a depth of 6 ft., with $2.75 added for each additional foot of depth. Extra brickwork in cement mortar in inlets and manholes cost $19.75. Two classes of concrete were used. The first consisted of one volume packed Portland cement, 2 volumes sand and 5 volumes broken stone, and was used principally in the pumping station building. The contract price for it was $9.15 cu. yd. The second class consisted of 1 volume of packed Portland cement, 3 volumes of sand and 6 volumes of broken stone, or of 1 to 9 cement and river gravel. The contract price for it was $7.90 cu. yd.

The contract prices on the levee work were 15.95 cents per cubic yard, for a free hand of 500 ft., with 1 cent per 100 ft. per cubic yard for overhaul. The average overhaul was about 2,950 ft., so that the total average price per cubic yard of levee work was 45.45 cents.

CONTRACT PRICE PER FOOT FOR CAST-IRON AND VITRIFIED-CLAY PIPE SEWERS, MEMPHIS, TENN.

Low Level Sewers			High Level Sewers		
Size vitrified pipe.	Depth.	Price.	Size cast iron. pipe.	Depth.	Price.
15-in.	0 to 4 ft.	$0.61	16-in.	0 to 4 ft.	$1.90
“	4 to 6 ft.	.70	“	4 to 6 ft.	2.05
“	6 to 8 ft.	.80	“	6 to 8 ft.	2.25
“	8 to 10 ft.	.95	“	8 to 10 ft.	2.50
18-in.	0 to 4 ft.	.77	24-in.	0 to 4 ft.	3.60
“	4 to 6 ft.	.87	“	4 to 6 ft.	3.78
“	6 to 8 ft.	.98	“	6 to 8 ft.	4.10
“	8 to 10 ft.	1.15	“	8 to 10 ft.	4.39
“	10 to 12 ft.	1.40	30-in.	0 to 4 ft.	5.25
22-in.	0 to 4 ft.	1.56	“	4 to 6 ft.	5.40
“	4 to 6 ft.	1.66	“	6 to 8 ft.	5.75
“	6 to 8 ft.	1.80	36-in.	0 to 4 ft.	6.90
“	8 to 10 ft.	2.00	“	4 to 6 ft.	7.10
“	10 to 12 ft.	2.25	“	6 to 8 ft.	7.30
24-in.	0 to 4 ft.	1.80	“	8 to 10 ft.	7.80
“	4 to 6 ft.	1.90	42-in.	0 to 4 ft.	...
“	6 to 8 ft.	2.05	“	4 to 6 ft.	...
“	8 to 10 ft.	2.25	“	6 to 8 ft.	...
“	10 to 12 ft.	2.50	“	8 to 10 ft.	...
“	12 to 14 ft.	3.00	48-in.	0 to 4 ft.	11.10
30-in.	4 to 6 ft.	3.10	“	4 to 6 ft.	11.35
“	0 to 4 ft.	2.90	“	6 to 8 ft.	11.60
“	6 to 8 ft.	3.55	“	8 to 10 ft.	11.90
“	8 to 10 ft.	3.95	Vitrified Pipe.		
“	10 to 12 ft.	4.55	18-in.	0 to 4 ft.	.77
36-in.	0 to 4 ft.	4.80	“	4 to 6 ft.	.87
“	4 to 6 ft.	5.10	24-in.	0 to 4 ft.	1.80
“	6 to 8 ft.	5.60	“	4 to 6 ft.	1.90
“	8 to 10 ft.	5.60	30-in.	0 to 4 ft.	2.90
“	10 to 12 ft.	6.60	“	4 to 6 ft.	3.10
“	12 to 14 ft.	7.35	36-in.	0 to 4 ft.	4.80
“	14 to 16 ft.	8.10	“	4 to 6 ft.	5.10
“	16 to 18 ft.	8.85			
“	18 to 20 ft.	9.60			
Total		$25,233.50	Total		$19,562.50

The contract price for the 8-in. pumping outfit was $1,635; for the 20-in. pumping outfit, $4,250, and for the 24-in. pumping outfit, $5,100; making the total cost of the pumping machinery $10,985. The contract price for the concrete building was $6,910. The final total cost of the pumping station complete was $25,000. The levees cost $52,000; the high-level sewers, $32,000; the low-level sewers, $35,000; changes to the domestic flow sewers, $10,000; real estate, $10,000; and street, bridge and miscellaneous work, $45,000; making the total cost of the works $209,000.

The protection works and pumping station were designed by Mr. J. A. Omberg, Jr., city engineer of Memphis, and were built under his immediate supervision. R. D. Wood & Co., of Philadelphia, Pa., were the contractors for the equipment of the pumping station. Messrs. Weatherford & Carey Bros., of Memphis, were the contractors for all of the sewer work and the erection of the pumping station building. Mr. P. H. Rogers, of Memphis, was the contractor for the levee work.

The Official Prussian Tests of the Jewell Water Filter.

The Royal Prussian Institution for the Investigation of Water Supply and Sewerage has conducted during the last two years a series of tests of the American or mechanical system of water purification. For this purpose the Jewell Export Filter Co. built an experimental plant at the Mueggel Lake station of the Berlin waterworks, at Friedrichshagen. The raw water of the lake is not turbid enough to enable a mechanical plant to show its full capabilities, but on the other hand this location permitted the experimental purification plant to be operated under conditions precisely like those of the large sand filters at this place, thus affording comparative data of much interest.

The raw water was raised to a pair of circular sedimentation tanks, each holding 2,378 gal. and capable of being operated independently of the other. Arrangements were provided for keeping the level of the water in the tanks at various heights, as desired. The filter was 4 ft. in diameter, of the standard type of this company, and arranged to operate at a rate of either 98 or 135 gal. per square foot per hour. Means were provided for the introduction of bacteria into the raw water before it reached the first subsidence tank. A 2 per cent. solution of sulphate of alumina was made up in an elevated tank which supplied a gravity box in which a constant surface elevation of the solution was maintained automatically; the quantity of the coagulant applied to the raw water was fixed by adjusting hard rubber cocks in the piping. The purified water passed through a Weston controller into an underground basin. The wash water was furnished from the municipal filtered water mains.

The experiments were conducted for the Institution by Dr. Karl Schreiber, who has lately published in its "Mitteilungen" an elaborate report concerning them. The technical part of the operations was supervised by Mr. E. A. Gieseler, who has prepared a careful translation of Dr. Schreiber's report, on which the following article is based. The report is accompanied by elaborate tables of experimental data.

Operations were commenced on Sept. 2, 1904, with an average dose of 1.17 grains of sulphate of alumina per gallon, a period of subsidence of three hours, and a rate of filtration of 98 gal. per hour. In the course of the experiments a number of tests were made by modifying both the dose of sulphate of alumina and the time of subsidence. While these modifications have rendered valuable results, especially in showing their influence in the treatment of plankton, the bacteriological results in 1904 were not altogether satisfactory. It is true, the number of germs in the effluent was nearly always below a hundred, but it was also higher than the number of germs in the effluent of the city water works. Again, the reduction of B. prodigiosus applied to the raw water was not as great as Bitter had found in his experiments at Alexandria. When the dose of sulphate of alumina was increased, it was then found that through this increase the bacteriological results were decidedly improved. The advent of winter, however, prevented further experiments.

On the basis of the information obtained in 1904 it was not possible to arrive at a conclusive opinion; the Jewell Export Filter Co. therefore decided to place the experimental plant at the disposal of the Institution for another series of tests to be made in 1905, during which continuous bacteriological investigations were to be made on the part of the Institution. The bacteriological work was entrusted to Dr. Hilgermann, while supplementary bacteriological, chemical and biological investigations were made at the laboratory of the Institution. Tests were commenced in the beginning of April, 1905, and were continued until the beginning of July.

The preliminary tests had shown that the chemical composition of the raw water does not undergo any material changes such as might exercise an influence on the efficiency of the filter. The number of germs was comparatively small, and did not vary much. Therefore, in order to test what influence a greater number of bacteria in the raw water would have on the number in the effluent, it was decided to artificially increase the number in the raw water.

The plankton contained in the raw water exercises a great influence on the clarifying effect of the filter, a fact which had already been noticed during the preliminary tests in the fall of 1904 without having at that time been systematically investigated.

During the preliminary tests it had been found that the time of subsidence could be shortened without impairing the results. It was therefore decided at the beginning of the tests to reduce the time of subsidence from the 3 hours employed in 1904 to 1 hour and 6 minutes, and when the results thus obtained were not found entirely satisfactory it was increased to 1 hour and 28 minutes. At the same time the rate of filtration, which, at the beginning of the tests in 1905, was 135 gal. per hour, was reduced to 98 gal. An investigation of the influence of the rate of filtration possesses no great interest, as sufficient data already exist on this subject. Rates of filtration of more than 120 gal. per hour may be employed in rapid filtration without impairing the results. For the clarification of potable waters rates between 98 and 120 gal. per hour are generally employed, that is, from forty to fifty times as much as may, on the average, be employed in slow sand filters.

The amount of sulphate of alumina applied appears to exercise the greatest influence on the efficiency of the filter. The preliminary tests had demonstrated that the water of Lake Müggel requires a greater dose than might be expected considering its comparative clearness, so it was decided to begin in 1905 with a dose of 1.34 grains per gallon, which dose was gradually increased to 2.52 grains.

The results obtained from modifying the method of applying the sulphate of alumina, that is, applying it either at the point of entry of the raw water into the subsidence tanks, or partly there and partly at some subsequent point in the course of its flow, have been considered as much as possible. It was found in 1904 that the point of application of the coagulant is principally important as respects the varying condition of plankton in the raw water.

Influence of Rapid Filtration on Bacteria.—In testing the efficiency of the plant, bacteriological investigation was naturally most important, and was conducted by the methods of the Imperial Health Office for the control of slow sand filters. In testing the raw water 0.2 and 0.1 c.cm. were plated, the results of the latter plating only being considered if the number of germs rose above 500. In testing the effluent platings were made of 1 and 0.5 c.cm., the results of the latter plating only being considered if the number of germs rose above 100.

Generally speaking the raw water was comparatively clear. The number of germs during the preliminary tests in 1904 ranged between 165 and 1,028, and averaged 454. In 1905 the number ranged between 110 and 850. At the commencement it was less than in the previous year, the explanation of which is that the preliminary tests took place in the fall, while the tests of 1905 took place in spring. It is probable that the plankton of Lake Müggel exercises a considerable influence on the number of bacteria, as the dead plankton serves as food for them.

During the preliminary tests in 1904, a subsidence of three hours was generally employed, and by this means an average reduction of about 37 per cent. of the germs was attained. The shorter periods of subsidence which were employed in 1905 exercised a correspondingly smaller influence on the reduction of germs. In the first series in 1905, for a period of subsidence of 1 hour and 6 minutes, there was a bacteriological reduction of 14.3 per cent. During the following series a duration of subsidence of 1 hour 28 minutes resulted in a reduction of 20 per cent. The percentage of improvement thus effected was small, and, considered merely from its influence in reducing the number of germs, the employment of subsidence would not be justified; it is, however, necessary for other reasons.

Considering the results which have been secured by counting the germs in the effluent, we have to distinguish between the numbers obtained immediately after the commencement of a new run, and those obtained after the filter has reached its normal condition. When washing has been completed and filtering recommenced, then the first effluent consists of the clear water with which the filter was filled. This has received great numbers of germs which were detached from the sand grains during the process of washing, and therefore the number of germs in the effluent will be greatly increased soon after the beginning of the run. At the same time a new filtering skin is being formed in the upper part of the filter bed, and therefore, after a time, the number of germs in the effluent sinks rapidly.

In the tests of 1905 not more than 50 germs were, in any case, found in the effluent during the period from 30 minutes after the beginning of a run to its end, while the average for this period was very much smaller. During the first series of experiments (April), when the time of subsidence was only 1 hour 6 minutes, and the rate of filtration was 129 gal. per square foot per hour, with a dose of sulphate of alumina of 1.4 grains per gallon, there was an average of 32 germs per c.cm. If, during the whole time of experiments the dose of sulphate of alumina had not been varied, it might have been practicable to determine the influence of the increase of germs in the raw water on the number contained in the effluent. But as it was of paramount importance to study the influence of the sulphate of alumina, the dose of this was gradually increased.

In the first series of the experiments (April) the bacteriological reduction was only 85 per cent. During this series we have to consider not only the very short time of subsidence and the higher rate of filtration, but also the fact that the filter was not yet in normal working order. Leaving, therefore, this series out of consideration, we find that with a subsidence of 1½ hours, and a rate of filtration of 98 gal. per square foot per hour, there was never effected a smaller reduction than 90 per cent. As the dose of sulphate of alumina was increased the reduction rose from 91.3 to 95.4 per cent. The greater dose of sulphate of alumina has the effect of bringing about more rapidly a practical constancy in the number of germs during the run.

In order to determine the influence of the number of germs in the raw water on their number in the effluent, it was necessary to artificially apply germs to the raw water, as the number contained in it naturally was small and varied little. For this purpose a bottle filled with broth was inoculated with raw water and kept for several days at room temperature, so that a large multiplication of the germs took place. This broth was then continuously applied to the raw water at the point of entry into the subsidence tanks.

The number of bacteria found in the effluent during these tests are astonishingly small when compared with the great number contained in the raw water. The results of a few days must be left out of consideration, because undoubtedly something went wrong with the operation of the plant. The gradual increase of germs in the effluent is due to their great number in the raw water. Similar experiences have been noted in slow-sand-filtration where an increase of germs in the raw water, if it exceeds a certain limit, for instance 10,000 per c.cm., is generally followed by an increase of germs in the effluent. The average result of all experiments shows that the effluent contains 63 germs per cubic cm. as against 15,080 in the raw water, a reduction therefore of 99.6 per cent.

The number of germs in the effluent has been found to be a safe indication of the efficiency of a slow-sand-filter. If, therefore, with one and the same raw water a rapid filter renders the same reduction of germs as a well conducted slow sand filter, then the conclusion is justified that the efficiency of such rapid filter in removing pathogenic bacteria is the same as that of the slow-sand-filter. In Friedrichshagen it was possible to directly compare the results of slow-sand-filtration with the result of the experimental plant.

The number of germs found in the effluent of the municipal water works in 29 counts averaged 21. The average number in the raw water was 368, the reduction through slow-sand-filtration therefore amounted to 94.3 per cent. Rapid filtration at the rate of 98 gal. per square foot per hour, with a previous subsidence of 1 hour and 28 minutes, and 1.97 grains of sulphate of alumina per gallon of raw water would render the same results for the water of Lake Müggel as a well-working slow-sand-filter plant. This must be pronounced as answering the strictest requirements, as it should be considered that the municipal water works in Freidrichshagen is one of the best conducted ones, and that the results attained by it are not equalled by all slow-sand-filter plants.

With 1.93 grains of sulphate of alumina the reduction of germs rises to 92.2 per cent. after half an hour, while with 1.52 grains the reduction of germs after half an hour amounts to only 87.7 per cent. A reduction of 90 per cent. is sufficient with a raw water containing so small a number of germs. Consequently it is unnecessary to waste the water for more than half an hour when using 193 grains. At times of epidemics, when the raw water is suspected of being infected, it might be well to waste the water for one hour after the commencement of a run. It is true that the fixing of this point of time is as arbitrary as the limit of 100 bacteria per c.cm. agreed upon by the Imperial Health Office, but until we are in possession of longer experience with rapid filters in municipal water supplies and their influence on epidemics, it will be well to be strict in the requirements concerning their efficiency.

Effect On the Plankton.—The amount of 1.93 grains of sulphate of alumina per gallon at Friedrichshagen is somewhat higher than those found sufficient for good results in other plants. In the United States 1 grain per gallon is generally considered sufficient. In Alexandria Bitter has obtained excellent results with a rate of filtration of 98 gal. per square foot per hour, and a time of subsidence of six hours when using 1.29 to 1.40 grains of sulphate of alumina per gallon. The reason why so much more is required for the water of Lake Müggel is to be found in its peculiar character, which differs in a two-fold way from most waters clarified by means of rapid filtration. Generally these contain clay in a finely divided condition, and it seems that this silicate of alumina is favorable to the efficiency of the filter, not only in aiding subsidence, but also in contributing to the more rapid formation of the filtering skin; also lake water is generally richer in plankton than river water. During the preliminary experiments in 1904, it was shown that the bacteriological effect of the filter was increased in proportion to the removal of the plankton from the raw water, provided that in its place a suitably increased dose of sulphate of alumina was applied. During the time that in 1904 only 129 grains were applied, difficulties arose whenever the raw water contained great masses of plankton. On the filter this would form discs of a brownish color from 0.2 to 0.3 in. in diameter. They consisted largely of Diatomaceæ, also of hydroxide of iron and hydrate of alumina, in which mixture minute drops of grease could be discerned. On account of their specific gravity it was difficult to remove these discs by washing. In 1905 the experiments were made in the spring of the year, when lake water generally contains less plankton; still at times it was present in considerable quantities. Notwithstanding this, the above described discs hardly made their appearance at all, probably due to the stronger dose of sulphate of alumina applied which caused the greater part of the plankton to settle in the subsidence tanks.

Rapid filtration of a water like that of Lake Müggel, with its changing condition of plankton, requires constant attention. The attempt was therefore made to eliminate these changes, and to reduce the contents of plankton in the raw water to approximate constancy. In company with Prof. Kolkwitz, Dr. Schreiber made some tests in this direction by passing the raw water through filtering cloth before its entrance into the subsidence tank. These experiments were successful in so far as the quantity of plankton was reduced to one-half. The Melosira and similar algæ, which are the ones most detrimental to the formation of the filter skin, were more especially removed. There was no time to conclude these experiments, but Dr. Schreiber thinks it would be of advantage to take them up on a more extensive scale.

Chemical and Physical Aspects of Rapid Filtration.—The action of rapid filtration in clarifying water is a chemical and mechanical one combined, the chemical action being produced by applying to the raw water a coagulant, generally sulphate of alumina. Carbonate of lime contained in the water changes this into hydrate of alumina and sulphate of lime, at the same time liberating carbonic acid. The chemical formula in accordance with which this takes place is the following:

$$Al_2 (SO_4)_3 + 3 Ca CO_3 + 3 H_2O = Al_2 (OH)_6 + 3 CO_2 + 3 Ca SO_4.$$

The hydrate of alumina which is precipitated in loose flakes fulfils a two-fold office. In the first place it serves to carry down with it the suspended particles in the subsidence tanks, and at the same time a great part of the soluble humic substances is eliminated. In the second place, part of the hydrate of alumina passes to the filter bed and aids to form a filtering skin.

The longer subsidence lasts, and therefore, the slower the current in the subsidence tanks is, the more mud will be precipitated. Bitter employed subsidence in Alexandria lasting from six to nine hours. This could be reduced very considerably at Friedrichshagen, as the water of Lake Müggel contains very little mineral matter in suspension, and therefore is generally nearly clear. As the duration of subsidence is of economical importance, Dr. Schreiber attempted in 1905 to find the shortest subsidence compatible with good results. Experiments were therefore commenced with subsidence lasting a little more than one hour, but he soon saw that on account of the plankton a somewhat longer subsidence would be advantageous. It was therefore extended to about one hour and a half.

Not all of the hydrate of alumina is precipitated in the subsidence tanks, but a great part of it is carried by the water on to the filter bed and there aids in forming the filtering skin. It is well known that in slow sand filtration the so-called filter skin resting on the sand bed is not the only active agent in filtration, but that the upper strata of the filter bed also contribute to retaining bacteria and other suspended matter. The conditions in rapid filtration are similar. But while in slow sand filtration the formation of the filtering skin and the suitable preparation of the upper sand strata are due to plankton only, this process in rapid filtration is artificially accelerated by the hydrate of alumina. Thus the filter enters on its period of full efficiency half an hour after the commencement of a run, while in slow sand filtration this takes several days.

If the cross-section of the filter bed is studied at the end of a run, a brown mud skin several millimetres thick will be noticed which rests on the surface of the sand and adheres to it so closely that it is hard to remove. The upper sand strata also have a darker color, but at a depth of 10 cm. (4 in.), the unaided eye can no longer detect any impurities in the sand. The upper skin contained comparatively little organic matter and consisted microscopically of hydrate of alumina and plankton. Both these constituents as well as bacteria, decrease as we get lower into the filter bed. Still, even in the deeper layers, slight traces of hydrate of alumina and of plankton were found.

By means of washing, nearly all hydrate of alumina is removed, and after washing there remain but few bacteria and plankton organisms. A certain quantity of the hydrate of alumina and of the plankton-slime adheres so fast to the sand grains that it is not removed by washing. But this is necessary for the efficiency of the apparatus, and the filter bed that has been filled with fresh sand must be operated for several weeks before it renders satisfactory bacteriological results. Only on the surface of the sand a somewhat greater quantity of bacteria, plankton and hydrate of alumina remains. This condition is to be explained in this way, that during washing the contents of the filter bed arrange themselves according to their specific gravity. Plankton, bacteria and hydrate of alumina are gradually washed out and the wash water rising through the filter sand which at first is quite turbid, very soon commences to clear. When it runs perfectly clear the entry of the wash water from below is closed, and the agitator stopped; the movement of the sand continues for a little while and then stops; the finer grains of sand and those the specific gravity of which is lessened by a coating of hydrate of alumina and organic substances, having been carried to the top, invariably form the surface layers.

After washing, therefore, the rapid filter differs radically and favorably from a slow sand filter filled with newly washed sand. In the former the remaining foreign substances have gathered near the surface, and the deeper layers are nearly entirely free of them. In the latter the newly filled bed consists of a mixture of sand uniformly impregnated with foreign matter, and for this reason alone needs a long time for the re-establishment of its normal working order.

The lake water contained very little suspended clay, so there was mixed every hour, 1 kilo of clay with 20 litres of water, and emulsions were made of 4 litres of this mixture in 10 litres of water, which were continuously applied to the raw water every 12 minutes. In this way 1 kilo of clay per hour became suspended in the raw water. The observations of turbidity were made by means of Jackson's candle turbidimeter. A uniform turbidity of the raw water was not reached until several hours after the beginning of the test. The turbidity thus obtained is greater than that of any raw water which is ever used for municipal supplies in Germany, as by means of slow sand filtration it is not possible to remove such clayey turbidities. By means of rapid filtration, however, this is done in a highly satisfactory way as the experiments discussed here have shown. The effluent was always absolutely clear during the entire duration of the test. In America, where river water holding much clay in suspension is frequently used for municipal supply, similar favorable results have been obtained, and Bitter's experiments in Alexandria likewise entirely corroborate them.

Rapid filtration will also remove some substances held in solution. It is generally supposed that humic substances which impart a yellowish color to the raw water belong to this class, although the fact that a great part of the color can be removed by the application of sulphate of alumina seems to indicate their nature as colloidal substances. In order to study the behavior of humic substances, 600 litres of a concentrated extract of peat were made and applied in the usual manner. The determination of color was made by means of the United States Geological Survey color apparatus. This gave the average color of the raw water during the experiment 68, which was not all absolutely removed. Practically the effluent obtained must be designated as colorless; it was not possible to determine the very slight remaining color by means of the apparatus. By means of slow sand filtration the removal of color is simply impossible.

A great part of the iron contained in the raw water is also removed by rapid filtration. Generally, it is true, the removal of iron can be effected by previous aeration and subsequent filtering through sand or gravel, for which process the use of sulphate of alumina may not be required.

Considering, now, the remainder of the dissolved substances as to their behavior during rapid filtration, we note in the first place the increase of the sulphates, which is caused by the application of sulphate of alumina. This is not considerable. The slight increase in sulphate of lime found in the water filtered through a Jewell filter is unimportant for potable purposes, as there are many waters containing far more sulphate of lime which are used for domestic and drinking purposes without any detriment to health. But the question might arise whether such water may also be used for technical purposes, especially for boiler supply. While an increase of permanent hardness is not desirable for this purpose, the increase under discussion here is too small to be objectionable. If a certain water did not require the removal of the incrusting constituents before the application of the small amount of sulphate of alumina which is used in the Jewell filter, then, generally speaking, it will not require such removal after this water has gone through the process of rapid filtration. A water, however, containing an insufficient amount of carbonate of lime might become acid, from which a number of disadvantages would follow, in the first place rusting of the pipes. But there is in this case a convenient and cheap remedy in adding milk of lime to the water.

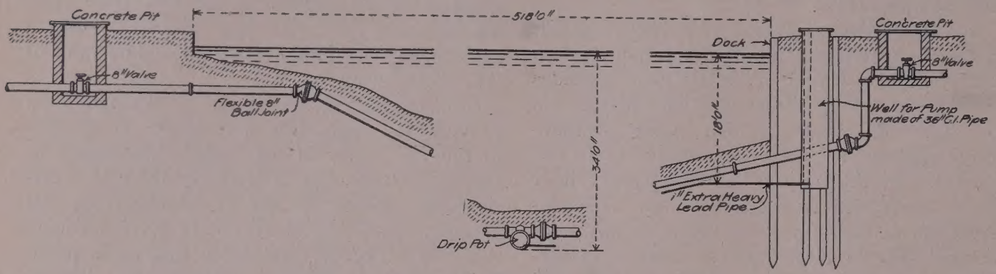
Hygienic Discussion.—From a hygienic point of view the application of sulphate of alumina to the raw water in the Jewell filter might be objected to; at least in Germany there is a certain bias against the use of chemicals for this purpose. Such bias, however, is not justified in this case. The only substance that could possibly be detrimental to health is the alumina, which forms only about 20 per cent. of the sulphate of alumina. Assuming a dose of 1.93 grains of the latter per gallon of raw water, and assuming further a consumption of 0.26 gal. of water per capita per diem, then during the whole year a person could possibly consume only 0.14 grain of alumina. Such small amounts of alumina may, however, be found in many waters that are considered unobjectionable for drinking purposes, especially in mineral waters. But even this small amount would reach the consumer only if the entire dose of alumina applied to the raw water would pass through the filter, whereas, as a matter of fact, so far from this being the case, in a well-conducted plant absolutely no alumina passes into the effluent.

Nor can the increase of sulphates incident on the use of sulphate of alumina be considered detrimental to health. In the first place it is very small; and, secondly, there are among the potable waters serving for municipal supply many that naturally contain much more sulphate of lime than has ever been demonstrated in the effluent of the experiment plant.

Technical Remarks.—It appears to Dr. Schreiber that the method of subsidence employed at the experimental plant was not particularly fortunate. The subsidence tanks have a two-fold purpose; in the first place to cause a more intimate mixture of the coagulant with the raw water, and in the second place to bring about a partial precipitation of the suspended matter. There were arranged in each tank three baffle-boards with the openings alternately on one and the other side. The intention of this arrangement is to force the water to follow a long sinuous route, but its disadvantage is that it has a number of dead angles in which the water stagnates; therefore, a part of the water will remain in the tanks a much shorter time than it would if the motion of all water particles were a uniform one. This he was able to demonstrate directly by an experiment with uranine. The theoretical time of subsidence was 88 minutes, but the uranine appeared on the filter only 40 minutes after it had been applied to the raw water. It is true that in a coloring fluid diffusion favors the rapidity of progress, and that suspended matter, such as clay, will not move as rapidly; still the experiment with uranine corroborates the above objection against the construction of the subsidence tank.

The setting of the coagulant taps was done by hand and required checking from time to time. In the Trieste plant (Eng. Record, Feb. 20, 1904), the amount of the coagulant is regulated in the same way. It might be desirable to introduce an appliance regulating the dose of sulphate of alumina automatically, so as to obviate the danger of fluctuations in the flow of the solution.

The filter and its appliance for washing is considered by Dr. Schreiber to be a model of technical detail; in fact the careful planning and designing of all detail parts is characteristic of the American systems of rapid filtration. An example of this is the Weston controller regulating the rate of filtration, of the entire reliability of which he has frequently convinced myself.

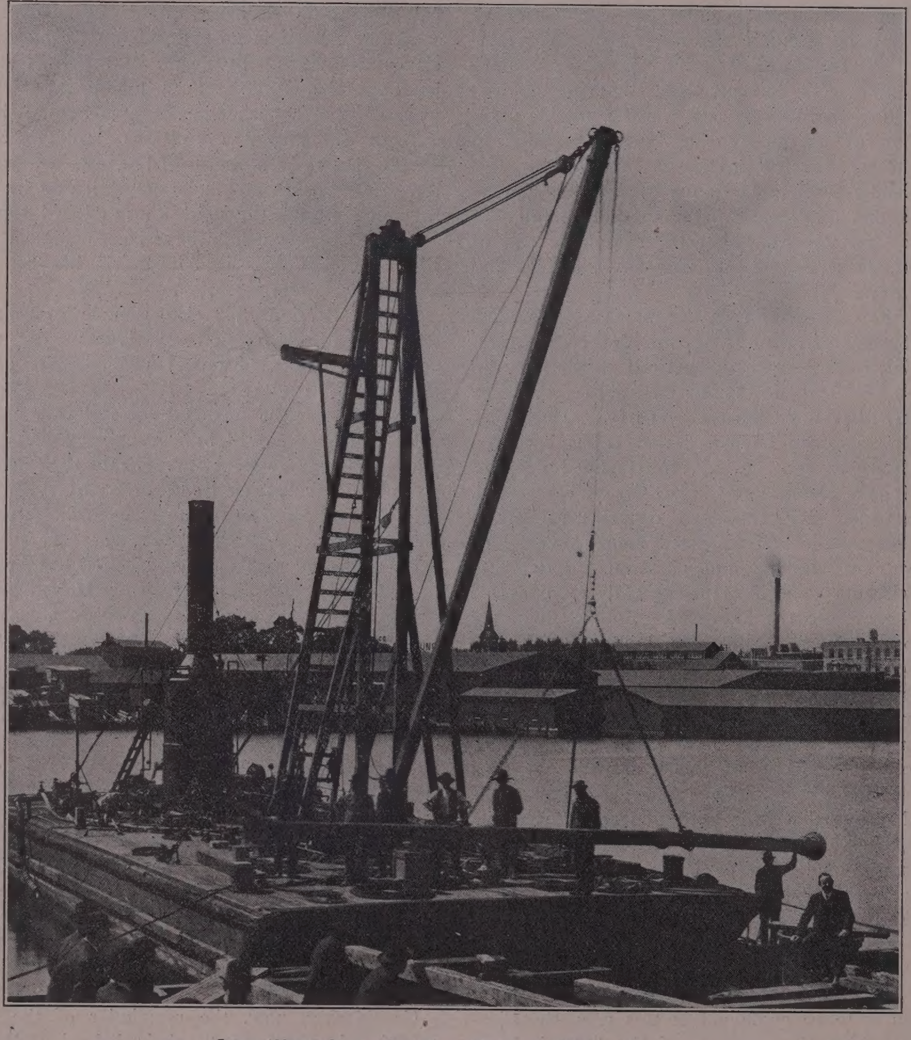


Details of Submerged Gas Main Crossing Under Fox River at Oshkosh.

Notwithstanding these great technical advantages, there have been disturbances during operation. But this is not to be wondered at, when it is considered that the investigators were operating with a small experimental plant and with comparatively inexperienced attendants. The agitator, which was operated by means of a crank, was a source of special danger. A blow on the crank would be imparted through the agitator rods to the filtering skin, and was apt to damage it. Such accidents are apt to happen in an experimental plant, but are readily avoided in a large plant.

Conclusion.—Summing up the results of the above described tests, Dr. Schreiber says that bacteriologically rapid filtration by means of the Jewell filter is equally as efficient as slow sand filtration, provided the operation of the plant is correctly adapted to the existing conditions; and in the removal of turbidity and color, the Jewell filter is distinctly superior to the old system. Even if there should remain in the minds of some an unjustified doubt as to its bacteriological efficiency, preference will, nevertheless, have to be given to rapid filtration in all cases where the question of available space is important, as, for instance, will generally be the case in mountainous countries. At Trieste the cost of a plant on the old system would have amounted to twice that of the rapid filter plant actually built. Similar considerations may be of vital importance in the case of storage reservoirs, where the water is impounded by means of a dam, and they will be of still more weight in the case of fortresses, the outlying water supply of which may be cut off in time of war, and where, for this reason, it becomes necessary to construct works well within the military lines for the supply of surface water, primarily river water. It is true, that in all cases where there is great variation in the composition of the raw water, notably as regards the presence of algæ, there will be certain difficulties in adapting the methods of operation to such changing conditions. But it should not be forgotten that in these matters slow sand filtration has the benefit of an experience of long duration. The experience obtained so far in rapid filtration has not as yet led to fixed principles in the treatment of raw waters of changing composition. In the case of such waters it may, therefore, become necessary to study, by means of an experimental plant, the methods of operation best adapted for maximum efficiency. Such an experimental plant should be arranged with a view to its becoming one of the units of the plant to be ultimately erected.

Concerning the cost of rapid filtration it is impossible to form an opinion on the basis of the results obtained with a small experimental plant. It is clear that cost of construction and of operation are very much dependent on local conditions, but on the basis of experience obtained in America it may, however, be assumed in general, that the first cost of a rapid filter plant will be less than that of the slow system, especially when the value of the required land is considered, and that the cost of operation will generally be somewhat higher.



Scow Used in Laying Gas Main at Oshkosh.

Taking it, all in all, the results obtained from the experiments with a Jewell filter at Freidrichshagen, have been satisfactory, according to Dr. Schreiber. The still better results obtained by Dr. Bitter at Alexandria are probably due to the different nature of the raw water there. From all of this it appears that more attention should be devoted to rapid filtration for municipal purposes than has been hitherto in Germany.

Laying a Submerged Gas Main.

An 8-in. submerged gas main was laid under the Fox River from Oshkosh to South Oshkosh, Wisconsin, during the past summer. The Fox River at the crossing is 525 ft. wide, has an average depth of 24 ft. and carries from 60,000 to 100,000 cu. ft. of water per minute, with a fairly swift current even at low stages. The gas main was laid for the Oshkosh Gas Light Co., by H. M. Byllesby & Co., engineers and contractors, of Chicago. It replaced an old wrought-iron main, and will supply South Oshkosh from a low-pressure coal-gas plant in Oshkosh. The old main had been badly corroded by the action of the acids produced from an unusual quantity of cinders which reach the river. The new main is made of standard cast-iron hub and spigot water pipe, with lead joints. Every third joint was made a flexible one to facilitate the laying and to permit the main to adjust itself to the bed of the stream.

Owing to the location of mains on each side of the river which had to be connected, and to the right-of-way obtainable, the submerged main is laid at an angle with the banks of the river. The bottom of the latter at the middle of the stream is rock overlaid with 18 in. of very soft silt. The depth at the middle is about 34 ft., which decreases considerably toward the sides, the gravel being covered by the same silt which covers the rock at the middle. A trench was excavated through the silt with a hydraulic jet handled by a diver. The jet was supplied with water under a pressure of about 140 lb. by a pump on a scow which was anchored over the point where work was in progress. An ordinary fire-hose nozzle, with a ½-in. opening, was used with good results.

The joints between three 12-ft. lengths of the pipe were made on the same scow on which the pump supplying the hydraulic jet was located. A flexible joint was also made at the same time on each of the sections of the main composed of the three lengths of pipe. The scow was anchored over the position each section thus assembled was to occupy, and the section lowered into place by a stiff-leg derrick mounted on the scow. The section was supported by chains at two points, one just beyond each of the two joints between the lengths of pipe, in such a manner as to keep it horizontal during the lowering. The flexible joints are of the Falcon ball and socket type, with bolted flanged connections having a lead gasket between the flanges. When a section of the main was lowered into place on the bottom of the river the flexible joint on the end next to the pipe already laid was made by a diver. The diver made the lead joints with a pneumatic hammer fitted with a caulking tool. The joints made on the surface were also caulked with the same tool, air power being supplied by a Blake compressor on the scow.

The rock came so close to the surface of the bed of the stream near the middle of the crossing that the pipe had to be anchored to it to insure safety against displacement. Holes were made in the rock on both sides of the pipe with a pneumatic hand drill by the diver. Expansion bolts were placed in these holes and strips of iron passing over the pipe attached to the bolts. After the pipe had been laid, the trench opened with hydraulic jet was soon closed up with silt by the river.

The submerged main is provided with a gate valve at each end on shore, in order that it may be cut out of service. A connection with an air compressor is also provided on the river side of one of these valves permitting the main to be tested for leaks. After the laying had been finished, these gate valves were closed and air under pressure of 60 lb. was turned on to test the joints. Whenever leakage of air occurred the diver went down and re-caulked the joints.

A 12-ft. length of 16-in. pipe, blanked at one end and attached by a flexible joint to the 8-in. main, was placed transversely at the lowest point in the latter, about 200 ft. from one shore, to receive whatever condensation may occur. A 1-in. extra heavy lead pipe is laid from this condensation collector to a well on the shore. This well is made of two lengths of 36-in. cast-iron pipe set on end and blanked at the bottom. The pipe well stands on piles and is kept vertical by 4 guide piles. The bottom of the well is 18 ft. below the normal river level and 16 ft. above the bed of the river at the length of transverse 16-in. pipe. The contractors guaranteed leakage, including condensation, not to exceed 4 gal per 24 hr. An actual test after the main was completed showed the leakage and condensation to amount to 2.75 gal. per 24 hr. A hand pump in the bottom of the well on the shore has sufficient capacity, of course, to remove this quantity of water, the suction lift being reduced to reasonable working limits by the well.

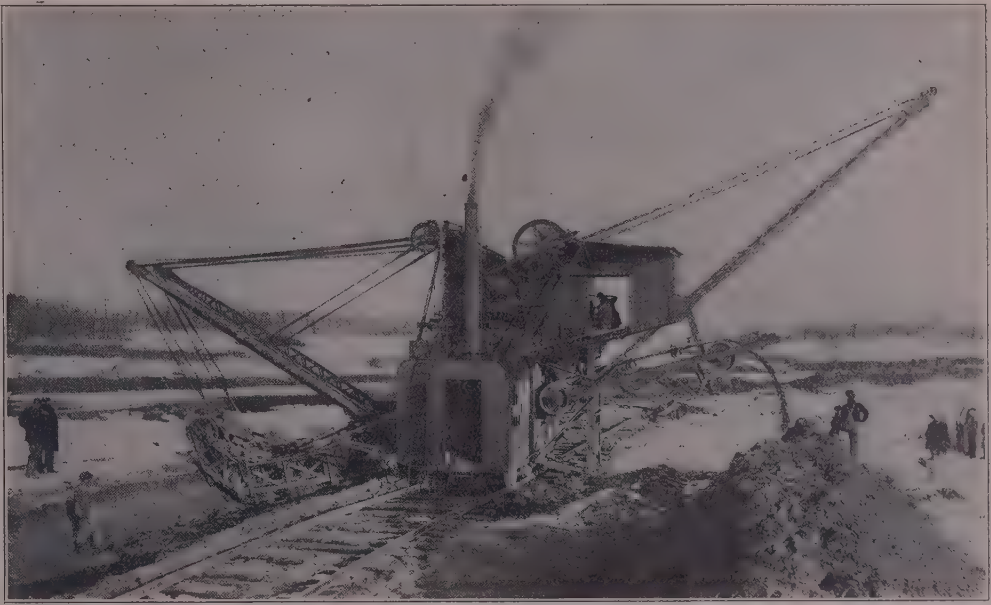
Lead pipe was used to make the connection between the length of pipe in which the leakage and condensation are collected and the well on the shore on account of the corroding action of the river water on wrought-iron pipe. Some electrolysis may occur in it, but not of enough extent to cause damage equal to that which would be certain to result from the corrosion to wrought-iron pipe.

A German Excavator on the New York Barge Canal.

By Emile Low, M. Am. Soc. C. E.

Work on the New York State barge canal is now in progress at six points in different parts of the State, Fort Edward, Waterford, Fort Miller, Sylvan Beach, Fox Ridge and Rochester, under contracts designated respectively as Nos. 1, 2, 3, 4, 5 and 6. Mr. Henry C. Allen, M. Am. Soc. C. E., Special Deputy State Engineer, is in general charge of the barge canal work.

Contract 4, one of three held by the Empire Engineering Corporation, of New York, lies in the western end of Wood Creek Valley, extending from the foot of proposed Lock No. 25 to deep water at the east end of Oneida Lake, at Sylvan Beach, a length of 4.83 miles. The canal prism between the points named is wholly in excavation, the water surface being that of the water level in Oneida Lake.



Excavating Machine at Work on New York State Barge Canal.

Section of New York State Barge Canal, Excavated by German Machine.

The depth of cutting at the mouth of Fish Creek, where it enters the lake, is 15 ft.; this is increased to 25 ft. at the foot of Lock No. 25, due to the gradual rise of the Wood Creek Valley, which is about 2 ft. to the mile. Wood Creek is a tributary of Fish Creek, the junction of the two being about 1 mile east of Oneida Lake, the former stream flowing from the east and the latter from the northeast. Borings made with a wash drill indicate that the valley is composed largely of fine, gray sand.

The adopted prism for this portion of the canal has a bottom width of 75 ft. with side slopes of 1 on 2 for a height of 9.5 ft., then there is a narrow offset or berme of about 2 ft., and above this the slope is 1 on 1½. This upper slope is protected by a wash wall of broken stone, the toe of which is secured by a series of piles, capped by walings, to which the top of a line of sheet piling is fastened.

On account of the canal prism being wholly in excavation, and the material to be excavated fine sand, a hydraulic dredge appeared to be the best plant for excavating the prism. The specifications require the excavated material to be placed in adjacent spoil banks, these to be of certain fixed widths and depths. To confine the pumped material within the prescribed bounds of the spoil banks, it was necessary to build two lines of dikes or levees parallel with the axis of the canal and at prescribed distances from it.

Generally there is a drainage ditch along the outside edge of the spoil banks, the material from these ditches being placed in the adjoining spoil banks, thus forming parts of the dikes or levees mentioned above. This excavation was done mainly by team scrapers and wheelbarrows. As the material from the ditches was not sufficient, the dikes or levees were augmented and strengthened by material from within the area occupied by the spoil banks. For material so obtained no allowance was made to the contractor.

A view of one of these ditches is shown in an accompanying illustration, the area of the proposed spoil bank being to the left of the center and the canal prism at the extreme left of the photograph.

In the beginning, material for the dike or levee next to the canal was excavated from the prism in the same manner as employed for the rear one. This method of excavation proved an expensive one, and in order to cheapen this class of work a type of excavator with transporter, built by the Lübecker Maschinenbau Gesellschaft, of Lübeck, Germany, was imported.

This machine consists essentially of an iron car, mounted on six wheels, running on a track of 2 meters (6.56 ft.) gauge. Within the car are placed the boiler, engine and driving mechanism.

One of the illustrations shows the machine in operation, building the inner dyke or levee, the one next to the canal prism proper. The boom on the left supports the elevator buckets, which excavate the material, carry it to the top of the car and dump it into a receptacle whence it falls on a rubber conveyor which carries it into the spoil bank. This conveyor is carried by the boom shown on the right hand of the machine. The machine is self-propelling, a sufficient length of track being always kept ahead of it. It has excavated 945 cu. yd. of sandy material in 7 hours, moving 315 ft. in this period of time. It requires a force of 3 men to operate it, an engineer, a fireman and a tender. One and a half tons of soft coal are required daily for fuel.

Improving the Boiler Plant at the Stratford Hotel, Chicago.

The Stratford Hotel at Chicago is a six-story 148x171-ft. building having fifteen stories and 250 rooms for hotel purposes. Until recently an attempt was made to furnish steam for the various purposes of such a structure by four return tubular boilers with flat grates and hand-fired furnaces, which had always given a great deal of trouble on account of smoke. The hotel is located on the lake front at the corner of Michigan Ave. and Jackson Boulevard, opposite Grant Park, which is one of the best sites in the city, and the smoke was accordingly a serious objection to the plant. When it was determined to put in new boilers, the engineer in charge of the work, Mr. A. J. Saxe, concluded that as the main object was to avoid any smoke nuisance it might be necessary to sacrifice some economy; when the plant was in place it was found, however, that not only was there no smoke, but about $10 a day was saved in fuel, although the consumption of current in the building, which was enlarged at the same time, was increased about one quarter.

The two new boilers are of the water-tube type of 300 h.-p. each, arranged with Murphy smokeless furnaces as shown in the accompanying illustration. Thermometer readings in the uptake just beyond the boilers show, with 140 to 150 lb. of steam, from 370° to 380° of heat, when the heating surface of the boilers is clean and never more than 390° when the flues are so dirty as to need blowing. The reason for this unusual result is stated by Mr. Saxe to be the long gas travel through the heating surface. It will be noticed in the drawings of the setting that the baffling is so arranged that the gases pass four times through the boiler lengthwise, thus remaining in contact with the heating surface four times as long as they would if the baffling were put in vertically in the usual manner. Instead of a travel of but 18 ft. through the heating surfaces there is one of 72 ft. Fears were expressed by some that, with this style of setting and boiler, the heat passing first through the back, the circulation would be reversed and the boiler caused to foam, but nothing of the sort has been observed. When crowding the boiler, the water is carried very steadily and cotton strings attached to the inside of the drums and allowed to remain there until the boiler was again opened showed the circulation to be from the front to the back as it should be.

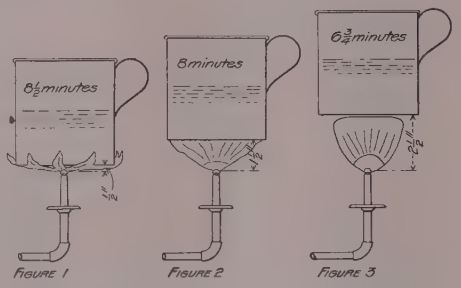
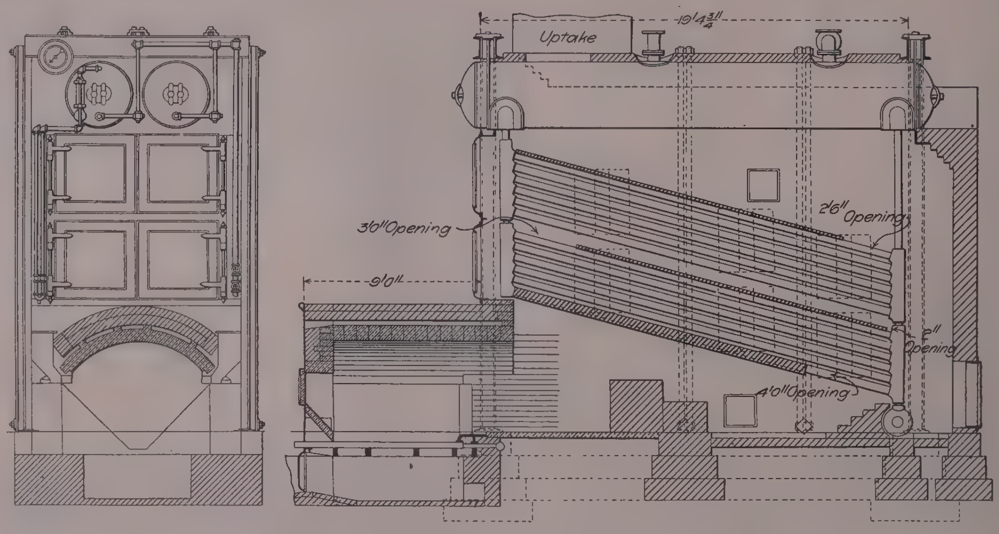


Figure 1 Figure 2 Figure 3

Evaporation by Different Flames.



Firing Details of Boilers at Stratford Hotel, Chicago.

Three diagrams have been furnished by Mr. Saxe to illustrate the action of the boiler setting at the Stratford Hotel plant. These indicate the results of experiments which anybody can duplicate. No. 1 is a cup with one pint of cold water at 55°. It was placed ½ in. above the tip of a common 2-ft. gas burner. The temperature was raised from 55° to 212° in 8½ minutes. This experiment made smoke and covered the bottom of the cup with soot. No. 2 was placed 1½ in. from the tip of the burner and boiled the water in 8 minutes and made some smoke and soot, but not as much as No. 1. No. 3 shows the cup of cold water placed 2½ in. from the gas tip. This boiled the water in 6¾ minutes, with no smoke or soot on the bottom of the cup, showing that combustion should have time to take effect before being chilled down by the cold surface of the vessel. This is the reason for placing the 23-ft. arch over the fire to prevent the gases from striking the comparatively cold heating surface of the boiler till after combustion has been completed. After that smoke cannot be made.

To get the best results Mr. Saxe believes some means of mechanical stoking must be used which will deliver an even supply of coal to the grates and a uniform supply of air. For large power plants he believes that the traveling grate is probably the cheapest furnace to operate for labor; but for hotels, office buildings, stores and factories, where there are large amounts of rubbish to be consumed, he prefers the Dutch oven type, as it has a large door in front where anything can be burned, while in many other styles of furnaces it is almost impossible to get anything into them except fine coal. Another advantage is that while running one boiler, which oftentimes happens in small plants, and sudden demands are made for steam, coal can be worked down by hand and the fires increased instantly.

Tests of the boiler illustrated were made in February. While using Illinois slack coal at $2.30 per ton, with about 11,000 B.t.u., 10 per cent. of moisture and 11 per cent. of ash, it cost 14.2 cents to evaporate 1,000 lb. of water. This, Mr. Saxe considers very good, considering the high price of the coal and its low heat value. The top of the stack is perfectly clear at all times while using the cheaper kind of soft coal.

It will be noticed that the drawings show an opening of 4 ft. for the first pass, 3 ft. for the second, and 2 ft. 6 in. for the last. Furnace gases will act the same as air, steam, water or electricity, and go where the resistance is the least, making the shortest cut from the inlet to the outlet. As it is an advantage to carry the gases as near the ends as possible, to get them into contact with the full heating surface of the boiler, these openings should be as close as possible and have sufficient draft, which was found in this case to be at about 0.2 in. in the furnace. The flue gases were sampled at 30-minute intervals and analyzed, and showed in some cases as high as 17.3 CO_2, which is almost perfect combustion. The average through the test was 15.4 CO_2.

The Falling of a Roof Tank, killing one person and injuring several more, which occurred in Montreal not long ago, again calls attention to the recklessness with which the enormous weight of these elevated reservoirs is often allowed to rest on flimsy supports. There seems to be a sort of deep-rooted belief among ignorant builders that a large tank and its contents weigh less on the roof of a building than they do on the ground, and a tower is run up about fit to use around a tree to keep horses from stripping off its bark. It is astonishing what a load such contraptions will carry when the wind does not blow, but as soon as the tower begins to sway in the gales and its joints begin to work loose, something is sure to drop and cause trouble.

Steel Piling Cofferdams for Bridge Piers.

A recent change in the alignment of the Norfolk & Western R. R. near Chillicothe, Ohio, necessitated the construction of a double-track, four-span bridge over a tributary of the Scioto River. The spans are carried by two stone-masonry abutments and three stone-masonry piers, the latter being in 3 to 6 ft. of water. The bed of the stream consists of gravel, ranging from ¼ in. to 8 in. in diameter. The gravel contains no sand or sediment so that a free flow of water takes place through it. The old bridge crossed the stream about 300 ft. from the crossing of the new one. The cofferdam in which the piers for the old bridge were built consisted of two rows of round timber piling, 6 to 8 ft. apart, driven around the site of each pier; waling pieces were secured to these rows of piles and a row of wooden sheet piling was driven along each row of round piles, then puddled clay was filled in between the two rows of sheet piling. Even with this comparatively heavy construction several large pumps were required to keep the water out of the cofferdams.

One of the Completed Cofferdams.

The cofferdams in which the piers of the new bridge were built were made of the steel sheet piling manufactured by the United States Steel Piling Co. The cofferdams were 16 x 62 ft. in plan, and each required 156 pieces of piling in 16-ft. lengths to build the same set of piling being used on all three cofferdams, without repairs. The sheet piles were driven with an ordinary pile driver, with a 2,000-lb. drop hammer, rigged on a scow. They were driven 14 ft. below the surface of the water, leaving 2 ft. of them above the water, 40 to 75 pieces being driven in a 10-hr. day by an ordinary pile-driving crew. The cofferdams were made rectangular. After all but 8 to 12 pieces had been driven, these last few pieces were assembled in place before driving so that the play between the pieces would allow some shifting which would permit all joints to come together and form a continuous coffer. These last few pieces, which were generally placed in one of the ends, would all then be driven to the proper depth. In driving the piling for one of the cofferdams a sound 10-in. sycamore tree root was cut through by the piling without difficulty.

Pumping Out One of the Cofferdams.

The most satisfactory method of keeping the sides of the cofferdam entirely water-tight seemed to be to place a dressed strip of poplar or pine, about ¾ x 1 in. in section, in the joint between the pile pieces. A piece a little thinner and wider was found to answer the same purpose, but either arrangement made the sides almost entirely water-tight. Some water came in through the gravel in the bottom of the cofferdam, but a 6-in. horizontal centrifugal pump running at about half capacity was capable of keeping this down. The pump was set on a platform at one corner of the cofferdam, and was driven by a traction engine mounted on a platform close to the latter. The platform for the engine consisted of 4 wooden piles capped with 12x12-in. timbers and covered with a 2-in. plank floor. The engine was run out from the shore to this platform and moved from cofferdam to cofferdam on a temporary trestle.

The excavation was carried 8 ft. below the water surface. White oak piles, 30 ft. long, were then driven to carry the masonry piers by the same driver that was used in sinking the steel piling. A 6x8-in. waling piece was secured to the inside of the cofferdam at the top. In the vicinity of the timber pile driving three transverse timber braces were placed between the waling pieces on the opposite sides of the cofferdam and were moved from place to place as the pile driving progressed, no bracing being required at other points to sustain outside pressure.

The wooden piles were sawed off 7 ft. below water by hand, and their heads imbedded in a layer of concrete, 5 ft. thick, on which the stone masonry was erected. A 5-ton guyed derrick and the pile-driving outfit were used in pulling the sheet piling after each pier had been completed. In driving the sheet piling for the first cofferdam the pile pieces were picked up from the shore and put into place for the pile driver by the derrick. This cofferdam was built in 3 days by the following crew: Foreman, at $5 a day; derrick engineer at $3; tagman, at $2; pile-driver engineer, at $3; and 6 men handling boat and pile driver, at $1.75; a total of $23.50 a day, or $70.50 for the 3 days. The same crew took 5 days to build the second cofferdam, making the construction of the latter cost $117.50. The main reason for the difference in time was the difference in facilities for handling the piling. In the second cofferdam the pile pieces were picked up on the shore and placed on the pile driver scow by the derrick. The scow was then towed to the cofferdam and the piling placed in position by the pile driver, instead of the derrick as before. These costs do not include the fuel account, plant rental nor the waling and braces used on the cofferdam.

The same steel sheet piles were afterwards used in making a cofferdam required in building a pier under a double-track bridge on the Baltimore & Ohio Southwestern R. R. at Ray, Ohio. This pier was built in the middle of a stream that had been scoured out to a considerable depth. In order to protect a trestle which the bridge replaces the railroad company had placed a quantity of rip-rap stone, ranging in size from small rock to pieces which would require two or three men to handle, in the bed of the stream. The piling was driven through a mass of this material, and in excavating in the cofferdam to a depth of 8 ft. below the water level, the bottom of the mass of rock was not reached, so it is not known to what depth the rock extended. Although the piling was driven with some difficulty through this material and through some buried logs that were also encountered, it was finally put in without much damage to the sheet pile pieces.

The work on the two bridge sub-structures was done by Mr. L. E. Sturm, railroad contractor, of Columbus, Ohio, and this journal is indebted to Mr. Sturm for the illustrations and the information given here.

The Hydraulic Laboratory at the University of Wisconsin.

The new hydraulic laboratory of the University of Wisconsin is on the shore of Lake Mendota, which borders the university campus on the north and immediately adjoins the university pumping station and tank house. An unlimited quantity of water is available for hydraulic experiments under low heads, and high heads up to about 170 ft. are provided by the university water-works pressure storage tanks. The bluffs of the lake at this point are about 50 ft. above the lake level, affording a site for a storage reservoir for moderate heads, which, while not yet constructed, is one of the accessories it is intended to add in the near future. The following notes concerning the laboratory are taken from an article contributed to the "Wisconsin Engineer" by Prof. D. W. Mead.

The foundation, basement, walls, columns and floor of the laboratory building are constructed of reinforced concrete. The walls of the building above the basement are of concrete blocks and the roof is an open truss type covered with red tile roofing.

The building consists of three stories, each 48 ft. in width by 98 ft. in length, including the basement, which is about 18 in. above the water level of the lake. In one corner of this basement is an engine room containing a pump to furnish large quantities of water under low heads for large flow, weir and water power experiments. This unit is a Morris centrifugal pump, direct connected to vertical twin engines and has a single 30-in. suction and 30-in. discharge. It draws from a 10-ft. canal leading directly from the lake and of sufficient depth to furnish water when the lake is frozen. The pump delivers into a receiving chamber of considerable size, from which the water may be taken for experiments under heads up to 10 ft. With this chamber are connected various conduits and channels by means of which investigations can be made on a scale of considerable magnitude concerning the laws of flow in channels and conduits together with the effect of the presence of dams, weirs, racks, submerged orifices and other features encountered in water-power work.

The receiving chamber is connected by double head gates with a channel or raceway 10 ft. in width and 10 ft. in depth, to serve for large flow experiments, and also as a head race leading to the larger turbine installation. In this channel flow measurements may be made with various depths of water in the channel as constructed, or with varying depths and widths by the temporary restriction of its cross-section. The volume of water available, which will be from 25,000 to 35,000 gal. per minute, offers a considerable opportunity for research work with reference to large apertures, weirs and racks.

In addition to this large channel, a small channel has been constructed 4 ft. in width by 4½ ft. in depth, parallel and adjoining the former. This will be used in connection with various channel experiments on a smaller scale, and also for the purpose of rating current meters and pitot tubes. Below this channel is a 30-in. circular concrete conduit where the phenomena of flow in closed channels may be observed.

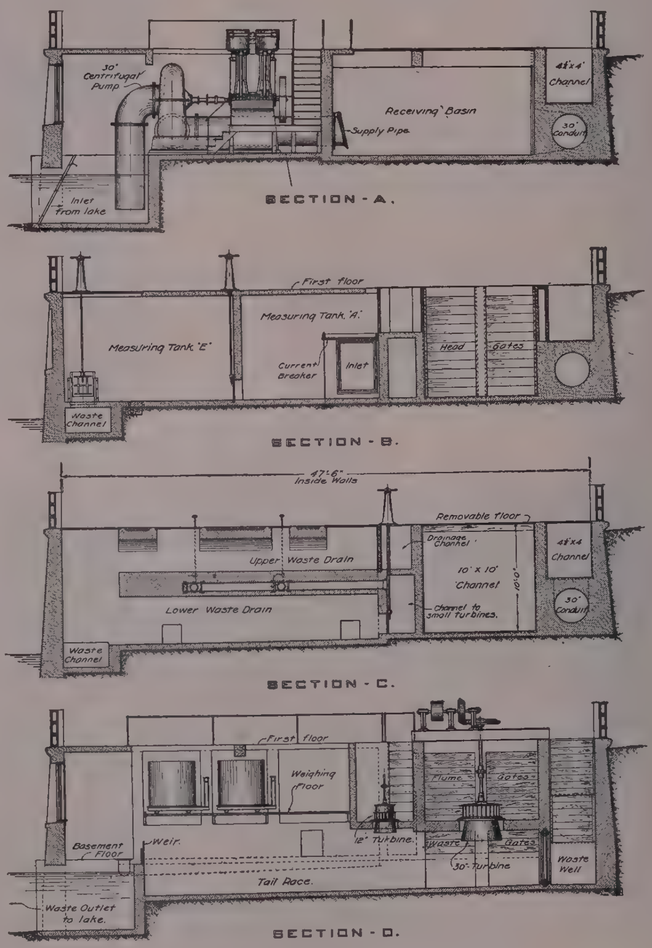
In addition to these permanent concrete channels a smaller wooden channel for similar purposes has been constructed on the main floor of the laboratory. A weir box at the head of this channel gives a measured quantity of water from which the relations of channel flow are obtained. The gradient of the channel is readily adjustable and the relations of volume, section and gradient can be varied, thus providing conditions more satisfactory for instructional work than with the large channels, but not of as much value for advanced and research work.

In the basement are five measuring chambers as shown on the plans. These are arranged so that they can be operated independently or in two groups. In the double grouping of the chambers each group will contain about 5,000 cu. ft., giving a total capacity of about 10,000 cu. ft. It is intended to use these measuring tanks in experiments where measurements of a high degree of accuracy are desired of considerable quantities of water. Their capacity will be carefully calibrated between definite points which will be accurately determined by hook gauges. In the volumetric measurement large discharges of water will be allowed to flow into a chamber or group of chambers until practically filled, then by closing one valve and opening another the discharge will be directed into another chamber or group of chambers while the first is being emptied. By this means experiments can be carried on for an unlimited period of time, and the errors of limited observations thus obviated. By means of proper floor openings these chambers can also be used as suction pits for pump experiments when desired. One group of measuring chambers is so arranged that they may be utilized for storage or experimental space when not desired for the purpose of measurements. They can be readily opened for such purposes, or closed and utilized for volumetric measurements.

In addition to these large permanent measurement chambers, movable tanks and scales are provided for the measurement of water by weight, for use in smaller volumetric observations.

Various weir boxes have been provided for the determination of weir conditions and weir constants. These are arranged to discharge into the measuring chambers in the basement, by means of which an accurate determination of the quantity of water flowing in a given time can be made. The weirs can be varied, with a range up to 26 in. in width and for heads as high as 18 in. In addition to the simple weir boxes there is also provided a double weir box for the investigation of the relations between various shapes of weirs and between free and submerged weirs. A fixed weir is constructed at the central partition, and may be duplicated in form at the lower end of the partition in a movable weir. By raising the end weir any degree of submergence within the range of the apparatus can be obtained in the center weir, and the effect of submergence on the discharge determined by proper comparisons. In addition to this, weirs or other openings of various shapes can be compared by using one of each kind in the two weir openings and observing the relations of the depth of water over each under uniform flow. A second combination of tank and weir boxes gives an opportunity to measure the losses in submerged orifices, and compare the flow with the flow of a standard weir over which the water passes after the orifice is passed. For weirs up to 26 in. in width and 18 in. in depth it is designed to make careful volumetric observations of relative discharge under varying head. For larger weirs and weirs of various arrangements of breadth and section, experiments will be made in the main 10-ft. channel. By admitting the water from the receiving chamber through a movable partition into measuring chamber A (see basement plan), the water may be passed over a number of standard weirs of smaller size, such as have previously been standardized volumetrically in the upper laboratory. By this means accurate determination can be made of the discharge of weirs of considerable magnitude in the main channel. It is also designed to arrange for experiments of considerable magnitude on the flow of water through submerged orifices and various forms of short conduits, such as are used in water power work. Studies will also be made of the effects of racks and other obstructions to the flow of water in this large channel.

Four turbines have been purchased, the largest of which, a 30-in. wheel, will develop about 50 h.-p. under the maximum available head. This turbine is located at the west end of the 10-ft. channel, from which it receives its water supply. The water, after passing the wheel, is discharged into a tail race 10 ft. in width, and in which a 5-ft. depth of flow will be maintained. In this tail race is arranged a standard weir. This weir, in connection with a prony brake on the wheel will permit of the accurate determination of quantities, velocities and efficiencies under various heads and conditions.



Transverse Sections of New Laboratory.

The smaller turbines are set in a separate wheel pit and receive their waters through a separate channel, discharging, however, at the present time into the same tail race as the larger turbine.

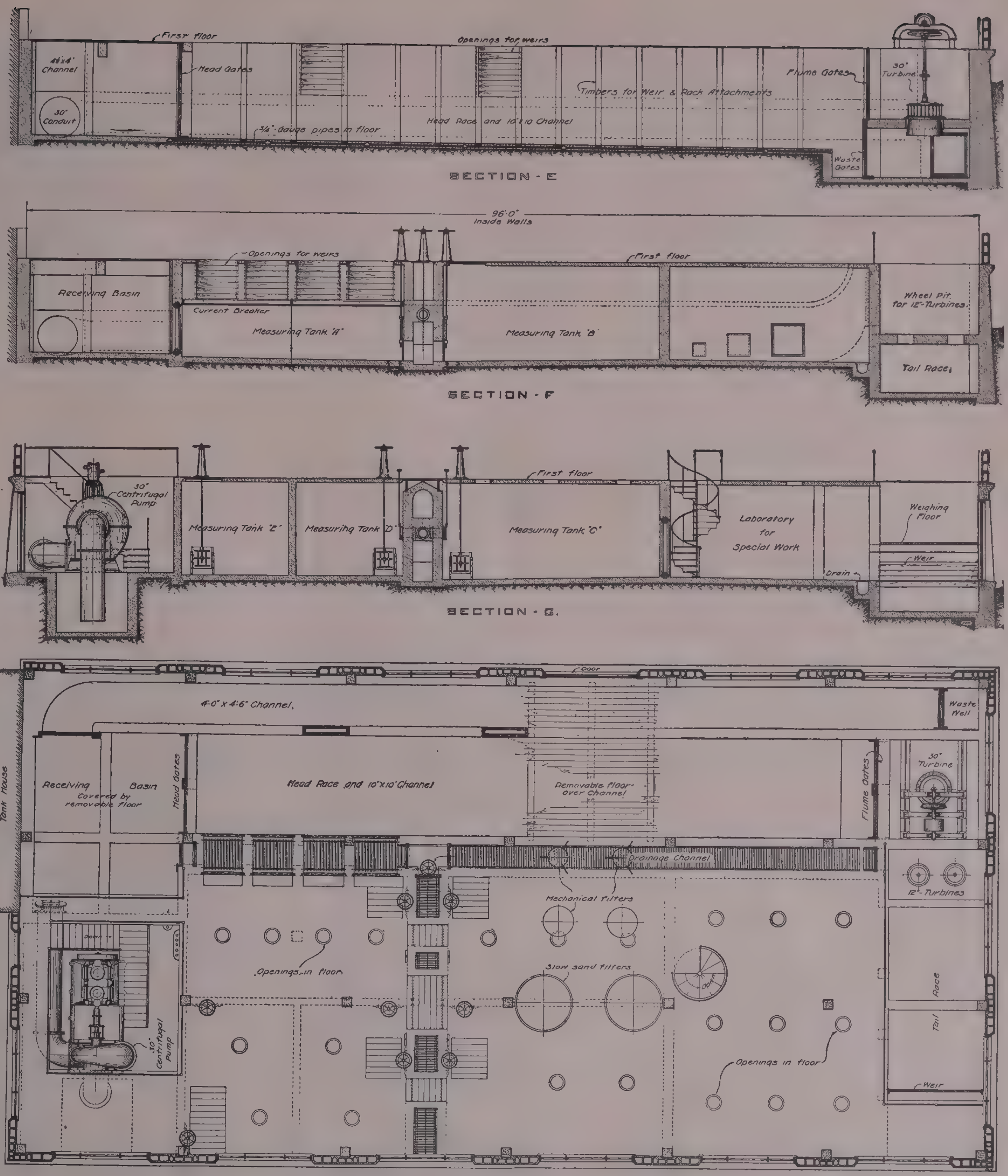
East of the hydraulic laboratory, directly connected with it and forming an integral part of the plant, are the university tank and pump houses. The pump house is equipped at present with one crank and fly-wheel compound condensing pumping engine, one compound direct-acting duplex steam pump and one high-pressure duplex steam pump. This station is soon to be reconstructed, greatly increased in size and provided with more modern machinery. The pumps deliver their water into the university mains, the excess being stored in the storage tanks under 78 lb. pressure. This pressure is maintained constant, both with and without the pumps, by air pressure from two air tanks, which contain air at a pressure of 100 to 150 lb. These storage tanks furnish water under the higher pressures needed for many experimental purposes.

From these tanks are operated two types of tangential wheels and a Girard turbine, besides several small water motors, and other apparatus for experimental work under high heads. The air tanks and the compressor that supply them are also to be utilized for experimental study of the air lift and other types of pneumatic pumps.

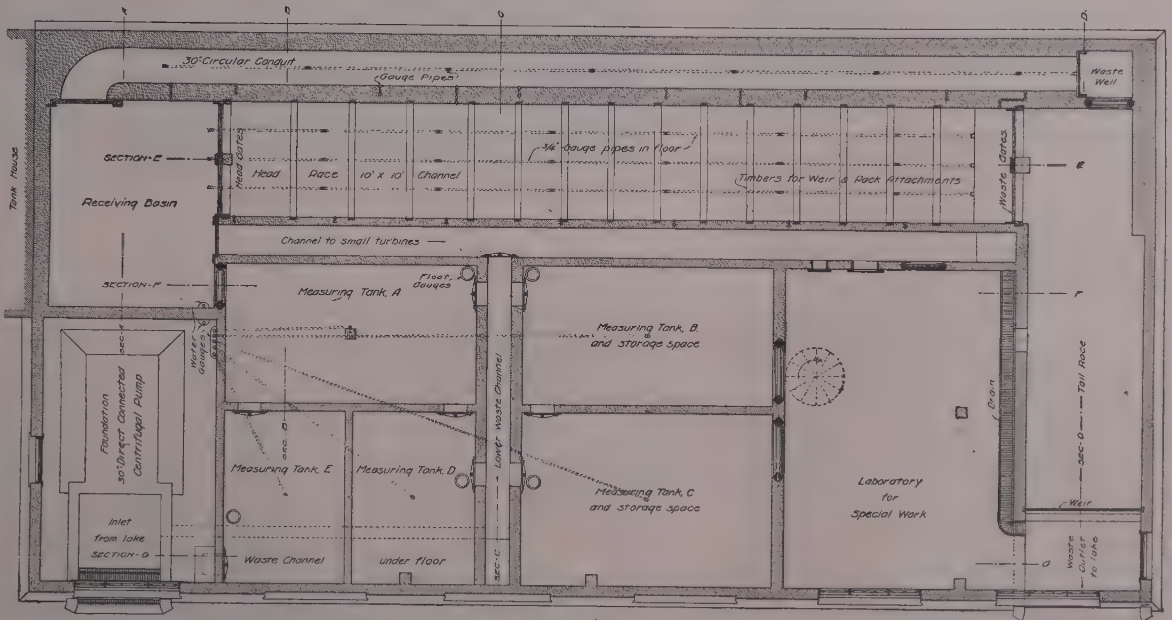
The laboratory is provided with two hydraulic rams. A No. 20 Rief ram which is in use for general experimental purposes is provided with a 2-in. drive pipe arranged in 6-ft. sections. The supply tank to the ram is adjustable and can be so arranged that it will supply water to the ram under heads varying from 18 in. to 10 ft. This variation in head and length of drive pipe, together with the variation in the pressure of discharge, gives a considerable range for experimental work and provisions are made for the accurate determination of the effects of such variations on efficiency and service. A new ram has been especially designed for experimental purposes and will be installed in the near future. In this ram arrangements will be made for variations in valve area, valve lift, air chambers capacity, etc., for the purpose of a detailed study of efficiencies under considerably greater heads and greater length of drive pipe than are now available. The new ram will also be arranged for 4-in. drive pipe, placing the experiments on a larger and more satisfactory scale. A smaller ram is provided capable of being worked under supply heads up to 50 lb. pressure, but with smaller quantities of water.

Two tanks are provided for the determination of the friction of water flowing through sand and gravel. Plans have also been matured for the construction of a larger sand tank by means of which the laws of the flow of ground water through sands and soils and the principle controlling the operation of wells can be studied.

In connection with the hydraulic and sanitary work, there has been provided in the laboratory, four water filters.



First Floor Plan and Longitudinal Sections.



Basement Plan of the Hydraulic Laboratory, University of Wisconsin.

Two are slow sand filters and consist of tanks 6 ft. in diameter by 8 ft. in height. A Jewell gravity filter has been purchased, and one mechanical filter containing Norwood strainers has been presented to the university by the Norwood Engineering Co. These filters have been fully equipped for experimental work.

Apparatus has been provided for the study of the flow of water in straight and curved pipes and hose of various sizes and materials, and also for the investigation of losses due to sudden expansion and contraction and to valves and other forms of restricted passages. The laboratory is also supplied with various reciprocating, centrifugal, vacuum and jet pumps and various water meters. A large assortment of accurate apparatus for the measurement of quantities, velocities and pressures, both in open and closed channels is available in the laboratory.

Arrangements have been made for the accurate investigation of various types of instruments and of the methods used in conducting hydraulic experiments.

On the upper floor of the laboratory, a 32x48-ft. lecture room will be equipped during the coming summer. This will be provided with apparatus by means of which many simple forms of experiments can be performed before the class in theoretical hydraulics, thus establishing by means of visible results the principles which can be impressed on the mind of the student only in this way. It is believed that a radical improvement in the method of teaching theoretical hydraulics can be made by this means, and that the information so conveyed will be of a more thorough, lasting and substantial character.

Special lines of important research work will be investigated by expert experimenters. One special line of experimentation which has been under way for about a year is in relation to centrifugal pumps. For this purpose a pump has been designed which is sufficiently flexible to admit of a wide range of change in detail. Six forms of cases have been designed, some of which can also be varied by the addition of various forms of fixed turbine blades. Twenty-four forms of closed impellers, in which the number and shape of the impeller blades vary, have been constructed. All of these are to be increased in number and varied in design as the results of the experimental work may warrant. This experimental pump is operated by a variable speed electric motor, and can be run at a wide range of speed. The motor current is determined by the most accurate forms of laboratory testing instruments, and the motor losses are determined with great care, so that the actual power reaching the pump is known with a considerable degree of accuracy. Provisions have been made for a careful study of pressures and velocities in the cases and passages of the pump, and the discharge is obtained over a carefully calibrated weir.

The object of this series of experiments is the establishment of the laws of flow in machinery of this type and the determination of the features which will result in high efficiencies and permit of the attainment of high heads. A special vertical type of centrifugal pump, intended primarily for deep well work, designed by Mr. John W. Alvord, of Chicago, has been presented to the laboratory by Mr. H. H. Porter, president of the Chicago Clearing & Transfer Co. It is also being tested in this series of experiments, which, it is expected, will also be extended to pumps of various standard designs and manufacturers.

Acetylene Gas without water is a new development, calcium carbide shaken with dry soda crystals being found to generate gas freely.

Expansion Troubles in Steam Piping.

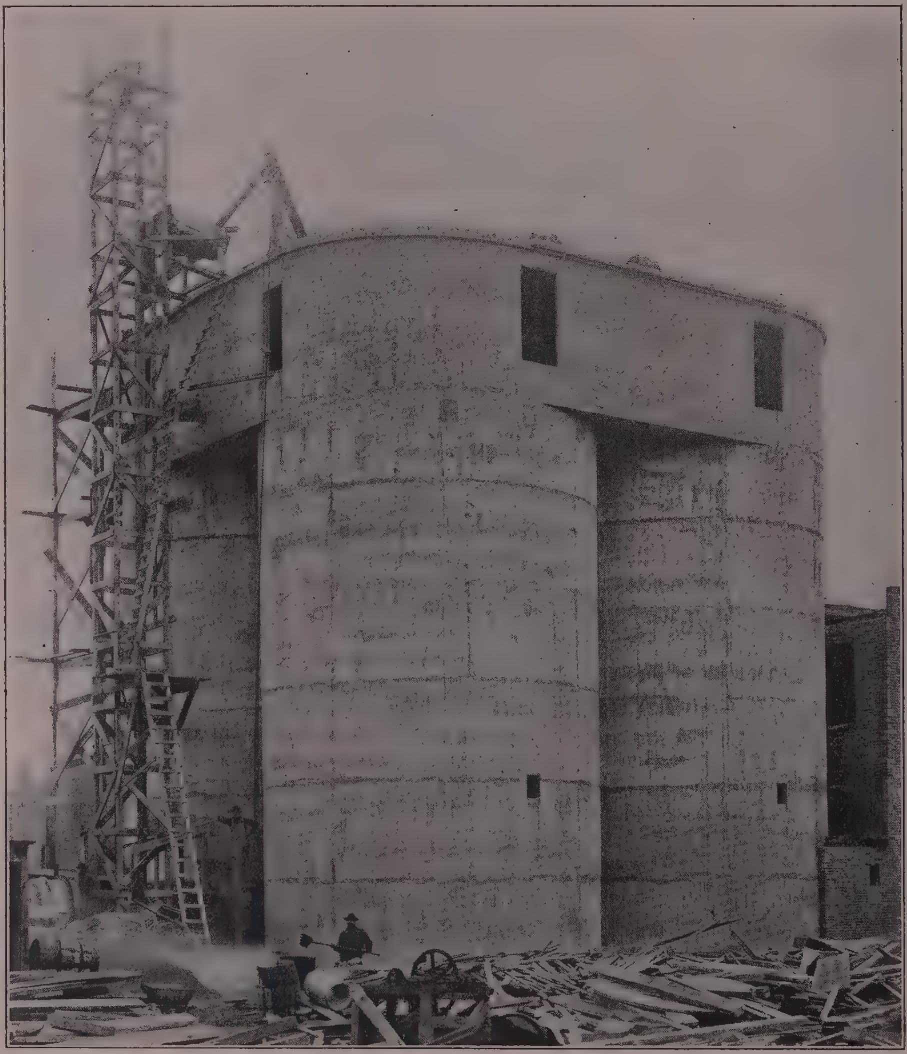
Expansion troubles in steam piping sometimes take on unusual aspects, but it rarely happens that a good precedent cannot be found for almost anything that arises. A recent inquiry concerning troublesome leakage under unusual conditions was answered by referring to a note published in this journal about ten years ago, which is worth recalling as a matter of general interest. It related to a case where it was impracticable to use slip joints, offsets or long-radius bends. A 14-in. main of extra heavy wrought-iron pipe with gun metal flanges ran horizontally for a considerable distance, and there it was supported on masonry foundations. At the end of this section the pipe rose vertically for about 30 ft., and then turned horizontally again for a considerable distance. This last run was supported from the roof trusses by hangers. The joints in the line hung in this way leaked badly and investigation showed that the expansion of the vertical portion, the effect of which was to lift the horizontal part and raise it from its supports, was the immediate cause of the difficulty. Heavy helical springs were placed beneath the nuts on the ends of the supporting irons, so as to assist in carrying the weight of the pipe. When this change was made the tension on the springs served to bring the supporting irons into continuous use, where before they were often inoperative, and the leakage disappeared.

A New Government Timber Testing Station has been established at the engineering laboratory of the University of Washington, at Seattle, where western hemlock will be tested.

Reinforced Concrete Sand Bins.

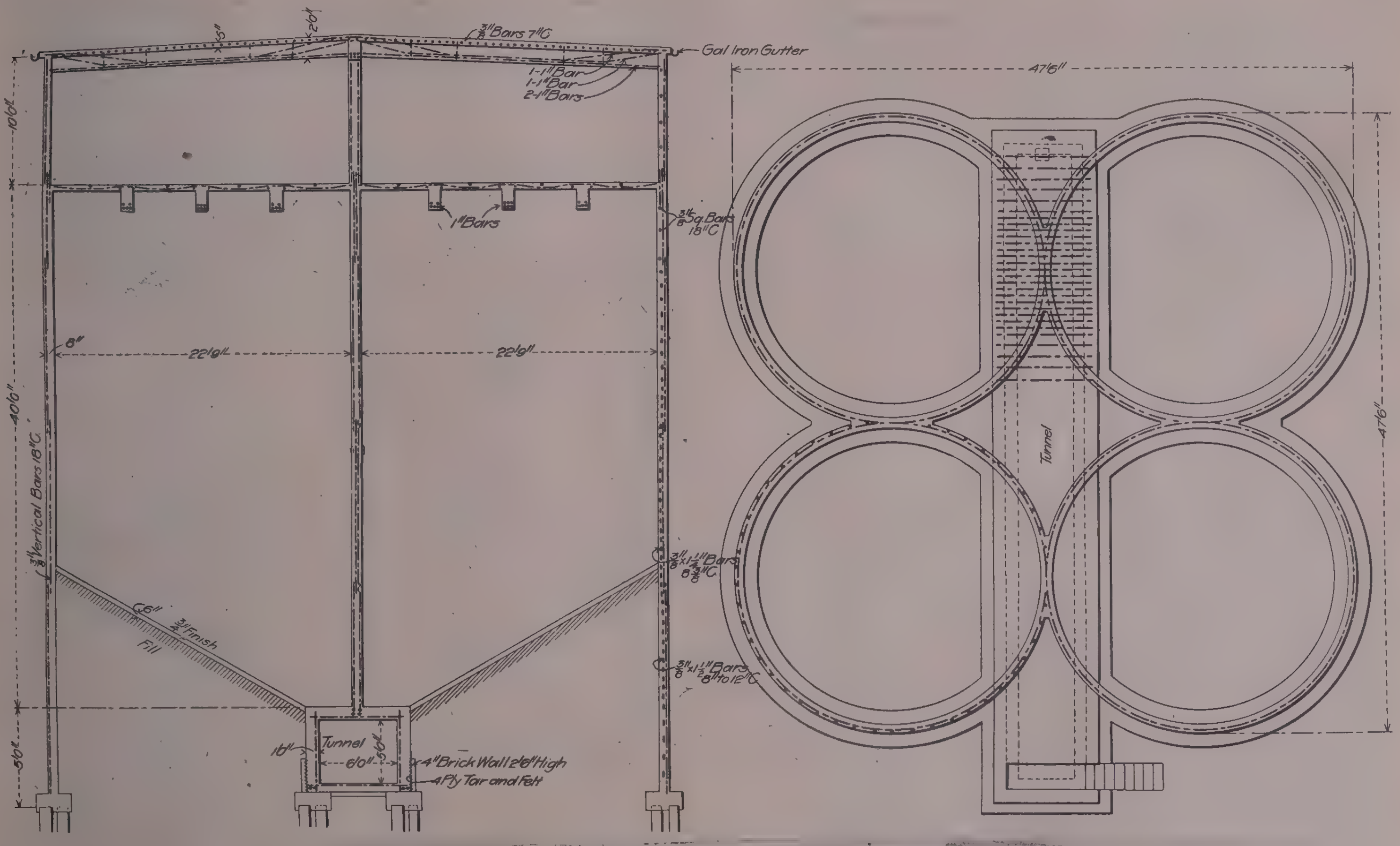
Reinforced concrete was recently selected by the Peerless Brick Co., of New York, for the construction of a cluster of sand-storage bins of 2,200 cu. yd. capacity at its plant at 118th St. and East River. It was essential to combine the maximum capacity with the minimum ground space. The design chosen provided a self-contained structure without bracing, which is practically a monolithic mass of concrete of simple construction, utilizing the space economically, while affording resistance for the stresses due to different conditions of the loading.

The main bins are four vertical cylinders with adjacent sides integral at the points of contact, as shown in the plan. The space between the bins is also available for service as a fifth bin. The bins have an extreme height of 40 ft. from their inclined bottoms to the top of a platform which covers them and forms the floor of an upper story provided with a nearly flat roof.



Reinforced Concrete Sand Bins, New York.

The bins are filled with sand delivered from scows by a belt conveyor to the upper or mixing story, and they discharge through 4-in. openings in the bottom to the belt conveyor operated in the tunnel beneath them. The steel reinforcement in the cylinder walls was proportioned according to the theory developed by Mr. J. A. Jamieson, of Montreal, in the "Transactions" of the Canadian Society of Civil Engineers. The upper floor is to be used both for lime storage and as an operating platform, and is proportioned for a working load of 400 lb. per sq. ft. The cylindrical walls have a uniform thickness of 8-in. and their 27-in. footings, 12 in. deep, are supported on two rows of piles 18-in. on centers, staggered 8 in. The walls are reinforced with vertical and circumferential Ransome bars, the former being uniformly ⅜-in. square and 18 in. apart on centers. The circumferential bars vary in size and spacing, as indicated in the sectional elevation. The roof and floor are of ordinary construction. The floor is carried direct by the tops of the cylinders and by six girders parallel to the axis of the tunnel. They are uniformly spaced and all have a 20x12-in. cross-section, exclusive of the thickness of the floor slab. The floor slab, 4¾ in. thick, is reinforced with crossed layers of ⅜-in. bars, 2 ft. apart parallel with the girders and 8 in. apart transverse to them except in the center between the four cylinders, where the 6-in. slab is reinforced by ⅜-in. bars 6 in. apart longitudinally and transversely.



General Arrangement of Reinforced Concrete Bins for Storing Sand in New York.

The roof is carried by the outer walls and by two 10x12-in. columns about 23½ ft. apart on the center line of the tunnel at the points of tangency of the cylinders. Each column is reinforced with four 1-in. vertical bars and has horizontal hoops 10-in. apart. The columns carry a main longitudinal girder parallel to the tunnel axis and two transverse girders. The third transverse girder is supported at the center of the longitudinal girder. The latter is 10 in. wide and 19 in. deep exclusive of the 5-in. roof slab and is reinforced with six 1-in. tension rods. The transverse beams, 8 in. wide and 15 in. deep, are each reinforced with four 1-in. tension bars. The roof slab is reinforced with ⅜-in. longitudinal bars 7 in. on centers and is covered with four-ply felt, tar and gravel waterproofing.

The vertical wall reinforcement bars are in lengths of about 14½ ft. and lap 18 in. at the joints, where they are wired together. The horizontal bars in the cylindrical walls are set just inside the vertical rods and are 1½ in. clear of the outer surface of the wall. Their ends lap from 12 to 16 in., and are separated by a ½-in. washer and connected by a ½-in. bolt at the center of each joint. The ends of the bars are bent outward 90 deg., and project 1 in. to secure additional grip in the concrete. The walls of the tunnel are reinforced with ⅜-in. vertical rods 2 ft. apart on centers and two ¾-in. horizontal bars are built in the lower edge of each wall to give it additional strength as a beam. The roof of the tunnel is reinforced with 1 in., and the floor with ¼-in. transverse bars, all of them 9 in. apart. The lower part of the walls and the floor are waterproofed with four-ply tar and felt protected on the outside by low vertical 4-in. brick walls. The bottoms of the circular bins are 6-in. thick and being supported directly on the solid back fill, are not reinforced.

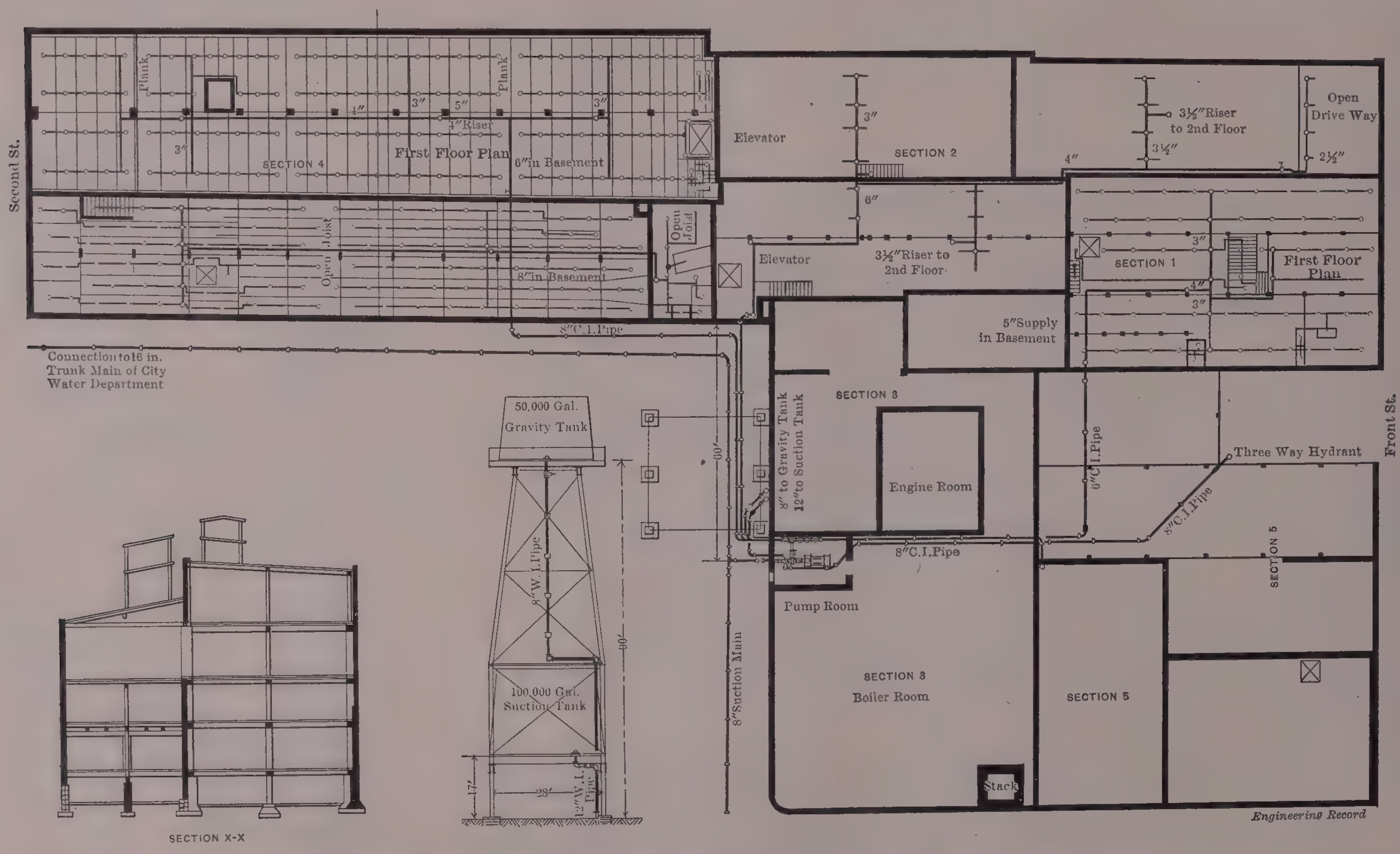
The 1:3:5 concrete was made with Lehigh Portland cement, Cow Bay sand and ¾-in. gravel, mixed wet in an 8-ft. Ransome machine driven by an 8-h.-p. Meitz & Weiss kerosene engine. The mixer was located at the foot of the elevator and delivered directly to an 8-ft. Ransome automatic dumping bucket, which was hoisted by the same engine and discharged its contents into an inclined concrete box carried up on top of the molds as the work advanced. From this box the concrete was delivered through a gate to wheel-barrows, by which it was distributed to the different parts of the work. The forms for the cylindrical walls were made in segments about 9 ft. long, of the inner and outer circumferences. They were 7 ft. in height, and were always filled with one day's work, amounting approximately to 42 cu. yd. of concrete. After the concrete was 24 hours old the segments were lifted successively 6 ft. by a small derrick carried on top of the work and were connected together for the next course. The joints between the different fills were bonded by vertical ⅜-in. bars 3 ft. long and 2 ft. apart on centers. The inner and outer molds were each stiffened with three horizontal circular ribs, one in the center and one at the top and bottom. The inside and outside molds were tied together by horizontal bolts. Radial kneebrace timbers about 10 ft. apart, were bolted to the walls just below the bottom of the molds and projected 4 ft. beyond it, both inside and outside, to carry working platforms. After the completion of the walls these braces were removed and the bolt holes left were carefully filled and pointed with mortar. The bins contain in all about 680 cu. yd. of concrete and 45,100 lb. of steel and were built in about 60 working days with an average force of 11 carpenters and 14 laborers. They were designed and erected by the Turner Construction Co., New York.

Effect of Frost on Open Filter Beds.

The uncovered filter beds at the Pettaconset station of the Providence water works, described in this journal on Sept. 24 and Oct. 1, 1904, have been so influenced by the frost during the past winter, although it has been an open season, that it has been determined to construct no more without covers. Seven beds have been in service and experience with them shows that the frost retards the rate of flow, increases the cost of cleaning and lowers the bacterial efficiency. Another bed has been practically completed, but before the sand is placed in it, a cover will be constructed. Two more beds have not yet been ordered, but when they are roofs will be constructed over them. When the works were designed it was uncertain whether covers would be necessary, and it was accordingly determined to go without them as an experiment, for by omitting them the cost of construction was considerably reduced. Another fact that the operation of the works has shown is that the silt in the raw water causes the sand beds to clog more rapidly than was anticipated; for this reason, it is probable that two more beds, making the full number of ten for which the works were designed, will be ordered before long. The beds have to be cleaned after three weeks' operation, instead of running four weeks, as was expected.

The New Mechanical Equipment at the Joseph Campbell Factory, Camden, N. J.

The Joseph Campbell Co. is one of the largest food-product manufacturers in this country, having an extensive factory at Camden, N. J., for the manufacture of condensed soups, mincemeat and the like. The factory is a model in mechanical equipment, cleanliness and the elimination of manual handling of all materials. Machines capable of automatically pasting labels on 240,000 cans per day, filling, capping and soldering machines with capacities of 24,000 cans per hour, and an extensive system of electrical handling machinery have been introduced. The extent of the company's business in 1905 exceeded 20,000,000 cans of soup, requiring over 30,000 lb. of butter, 400,000 lb. of beef, 200,000 lb. of chicken, and similar large quantities of the other ingredients.



Diagrams Showing Arrangement of Sprinkler System for Fire Protection, Joseph Campbell Factory.

The electric handling equipment recently added includes a system of traveling hoists in the process kettle department and a traveling crane in the broth room. The traveling hoist equipment serving the kettles consists of two motor hoists which travel on an overhead I-beam runway to transfer cans of soup after they have been properly filled and sealed directly to the process kettles without manual handling. The cans are filled and sealed by automatic machinery on the third floor, and for delivery to the kettles are packed in iron crates, each containing 850 sealed cans. They are then lifted by the motor hoists into the kettles and there sterilized by superheated steam, after which they are removed by the same hoists and lowered down through a hatchway to the second floor, where the cans are allowed to cool before being placed in the automatic labeling and boxing machines. An accompanying illustration shows a crate filled with cans hoisted over one of the sterilizing kettles ready for lowering into it.

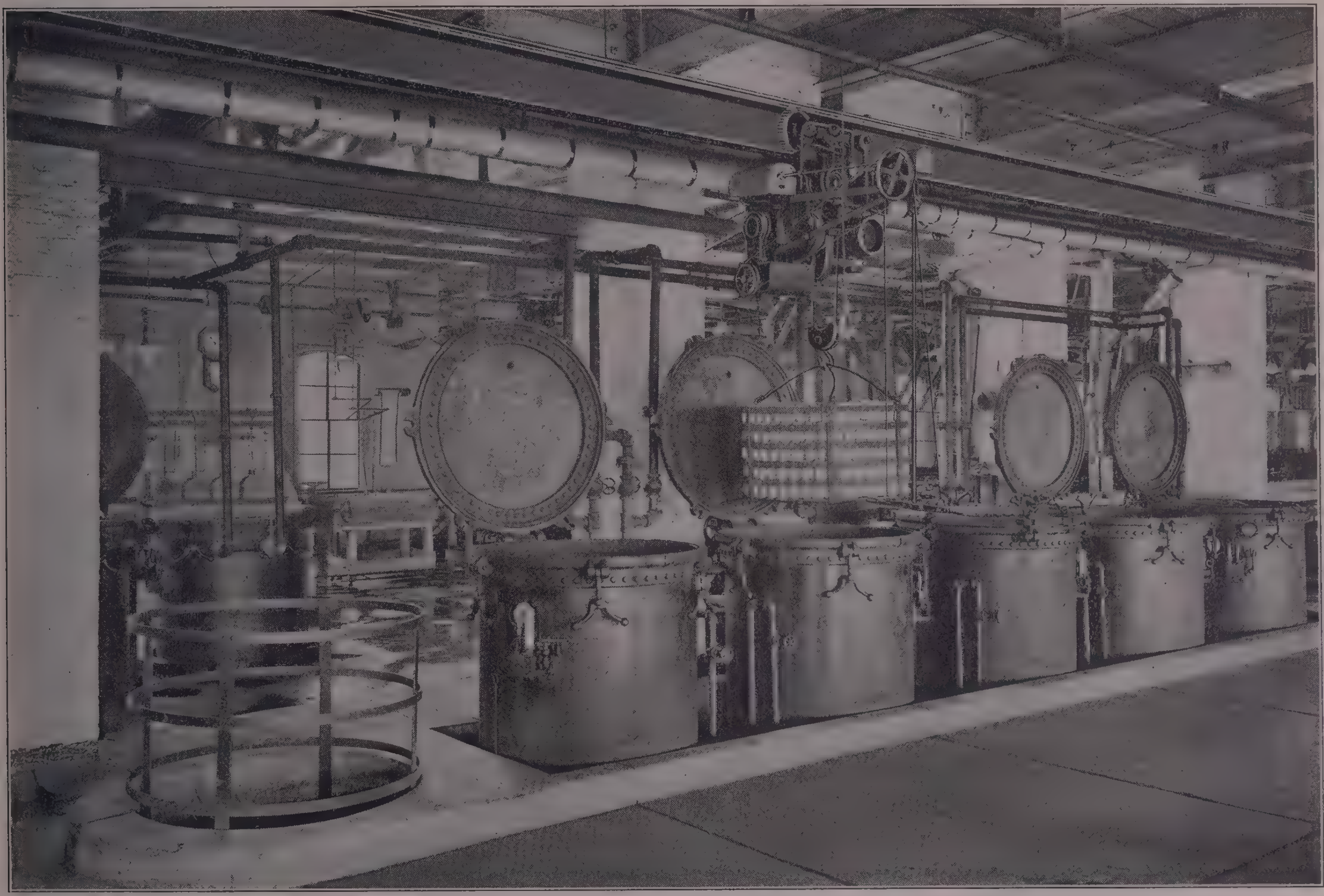
Each of these machines is a Sprague two-rope, two-motor traveling hoist, having a capacity of 1,000 lb., and hoisting drums designed for a total lift of 25 ft. Each has its drum mechanism under control of a slow-speed foundry-type controller with mechanical brakes, one having a maximum speed of 30 ft., and the other of 80 ft. per minute. Automatic safety limit stops are provided on each drum to shut off the motor when the hoisting hook has reached the highest limit of its travel. The trolley or traversing equipment of each, which is operated by a separate motor, is designed for a speed of 75 ft. per minute, and has a rheostatic controller with magnetic brake, having end-guard arms which will shut off the trolley motor when the hoist reaches the end of its travel or comes into contact with the other traveling hoist, and thus prevent damaging the motors. To further protect the motors each hoist is fitted with a circuit breaker.

The two hoists, one of which is illustrated in an accompanying engraving, travel on a 10-in., 25-lb. I-beam 10 ft. above the third floor level and 21½ ft. above the second floor level. This runway is 100 ft. in length covering the circular hatchway in the floor and the eight process kettles which project through the floor, each of a capacity for three crates containing 850 cans each. For the convenience of the operator in hoisting, traversing and lowering the crates into the kettles, there is a vertical controller shaft dropping from an overhanging bracket on the hoist at the front, which has a horizontal handle pivoted from the lower end with rope connections over pulleys to the hoisting controller. The connections from these to the controllers are such that tilting the handle in a vertical plane operates the raising and lowering mechanism, while revolving the handle in a horizontal plane so as to turn the shaft on its axis controls the trolley or traverse movements of the hoist, which latter operates through a bevel gear mechanism at the top of the shaft to operate the trolley controller directly.

The traveling crane in the broth room on the fourth floor handles the meat and supplies from the cutting blocks in different parts of the room into the broth kettles. This equipment was installed, however, under particularly unfavorable conditions of restricted head-room and floor clearances. The broth kettles are on an elevated platform at one side of the fourth floor under a monitor for lighting and ventilation, the roof proper at this point having a slope of 1 ft. in 20. To provide for a maximum lift for the hook, the crane mechanism was built with no projections above the crane frame and was mounted as near the ceiling as possible. This necessitated the use of a 12-in. channel runway on one side of the room with the lower flange for the runway in order to secure strength in the rail without projecting below and interfering with the head room; this runway is carried on a line of posts through the center of the room, the lower flange of the channel on which the crane wheels run being 12 ft. above the floor level. The opposite track, being carried on a side wall with greater clearances, was made of a 12-in. I-beam with the crane rail mounted on its top. The runway extends the full length of the room, 140 ft., the rails being spaced to give a span of 19 ft. from center to center of treads.

A three-motor crane of 1,000 lb. capacity, with an I-beam bridge and underhung carriage, is used. The bridge is built of two 10-in. I-beams with 8-in. channel bottom plates on each for stiffening and to provide runways for the trolley carriage. The latter is a type D motor hoist with a rheostatic controller and is designed for a traversing speed of 75 ft. per minute. Its hoisting equipment is operated by a foundry type of controller with a magnetic brake, and has a hoisting speed of 30 ft. per minute. The bridge movement is operated by a type N crane motor with a rheostatic control and mechanical brake, which is geared to give a bridge speed of 100 ft. per minute. The entire crane and motor hoist installation has been made by the Sprague Electric Co., New York.

The crane motors are all operated on the 110-volt power and lighting circuits of the factory, which are supplied from a 50-kw. General Electric dynamo in the power plant. Steam is furnished by one 300-h.-p., two 200-h.-p., and one 400-h.-p. Babcock & Wilcox inclined water-tube boilers, all equipped with superheaters, and furnish steam at 80 lb. pressure with from 50° to 100° Fahr. superheat. A 150-h.-p. Watts-Campbell simple Corliss engine drives a short section of line shafting in an adjoining building from which the generator is operated through a belt drive. This generating equipment is supplemented by a 10-kw. De Laval steam-turbine with twin generators, which delivers direct current at 110 volts; this unit is, however, used principally for night lighting, and serves also for reserve capacity. The greater part of the factory is motor driven, many of the power-driven machines having individual motor drives, and in other cases where sections of line shafting are used, the sections are driven by motors. The motors range from ¼ to 20 h.-p. and were furnished by the General Electric Co., with the exception of those used on the elevators.



Overhead Runway and Electric Trolley for Carrying Filled Cans to the Process Kettles.

The company uses superheated steam in the jackets of the process and cooking kettles, and the boiler pressures and superheats previously mentioned are said to produce the most satisfactory results in cooking and the greatest heating capacity with a given size of jacket and rate of condensation. The quantity of condensation to be handled from the kettle jackets is reduced by upwards of one-fourth under these working conditions. Individual steam traps are used for draining each of the kettles, of which there are over forty of over 220 gal. capacity. This condensation is returned by gravity to a 1,500-h.-p. Webster open feed-water heater where it is heated by the exhaust from the main engine and pumps for return to the boilers.

A complete sprinkler system with 2,850 heads has recently been installed in the factory for protection against fire. It conforms to the latest requirements of the Suburban Underwriters' Association of Philadelphia, and is fed by gravity and also an underwriters' pump. The wet system is used, as there is no danger of freezing, all portions of the building in which sprinklers are installed being heated throughout winter weather to prevent damage to the food products by cold. The sprinkler heads are in most cases mounted beneath open joist framing and their arrangement is staggered, each head covering a floor area of 40 to 65 sq. ft. The arrangement of buildings, the supply piping and the connections to street mains are illustrated in an accompanying engraving.

The water is drawn from the city mains and stored in a 50,000-gal. and a 100,000-gal. tank, both mounted on a steel tower in the factory yard. The tanks are both of wood, the smaller having its outlet connection 90 ft. above the ground level, while that of the other is 17½ ft. The smaller or gravity tank maintains a direct pressure on the sprinkler mains at ground level of about 45 lb., while the larger or storage tank provides an ample reserve supply from which the underwriters' pump may draw in case of scarcity or failure of the city water supply. As the underwriters' pump delivers 1,000 gal. per min., when operating to its maximum capacity, this tank will supply it in case of a total failure of the city water supply for a minimum of 100 minutes.

The connections to the city mains consist of an 8-in. pipe to a distributing main at the north side of the factory and an 8-in. connection to a 16-in. trunk main at the rear of the factory, from which no other service connections are taken off. These sources of supply are supplemented by a Siamese steamer connection to the pump delivery, to which the city fire engines may couple in case of fire and augment the supply by pumping into the system.

The 18x10x12-in. duplex underwriters' pump was built by the Barr Pump Co., and has a capacity of 1,000 gal. per minute or four good 1⅛-in. streams. It is located in a 12x18-ft. fireproofed room in the corner of the boiler room nearest the water tank tower. It has double 12-in. suction connections, one a line into which the two 8-in. supply connections from the street mains are joined, and the other a suction riser to the 100,000-gal. tank. It is the purpose of the system to draw first from the city water mains in case of a fire, the large suction tank connection being normally kept closed. The pump has an 8-in. discharge header from which the six branch connections to the sprinkler systems in the various sections of the factory are taken off. Steam is constantly kept up in at least one of the boilers to supply the pump if required. The pump delivery system has also connections to a yard system with independent gate hydrants, which may be used to fight fires in adjoining properties if necessary.

The side walls of the pump room are 18 in. thick and automatically closing fire doors isolate it from the remainder of the building. The ceiling has been built of a minimum thickness of 24 in. of concrete arches on 18-in. I-beams spaced 30 in. center to center. This is intended to withstand the blow of a falling roof or walls, and protect the pumping equipment from both heat and mechanical injury.

The sprinkler system has been laid out in five sections, as indicated in the accompanying plan. Section 1 is the office building; section 2 the L-shaped portion adjoining the rear of the office; section 3 the boiler room and mechanical plant; section 4 the large four-story division at the rear; and section 5 the group of buildings at the front of the boiler room.

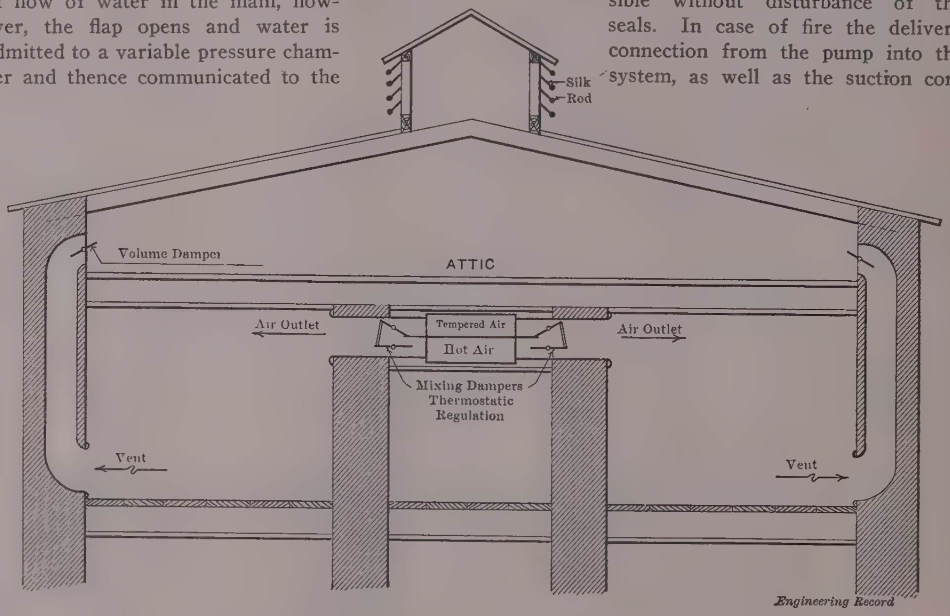
The office building, section 1, is a 50x80-ft., three-story and basement structure of open joist construction sheathed on the upper floors, and with a flat roof. It is served by a 6-in. connection from the pump room supply header, which connects into a 5-in. riser and main leading to the basement system, and from this main a 5-in. riser is carried up to the first, second and third floor systems. The system has been laid out on each floor and basement with cross-connecting feeders from the riser to the longitudinal sprinkler-head lines, of which there are six on each floor level, spaced 8 ft. apart on the average. The sprinkler heads on the longitudinal lines are 5 to 8 ft. apart so that no sprinkler covers an area greater than about 65 sq. ft. The staggered arrangement of sprinkler heads is used where the ceilings are unfinished and the rough floorbeams exposed, so that the spray will be distributed to a much greater extent than is possible with the arrangement of heads in opposite or parallel rows. In the finished section of the building on the second floor, the sprinkler arrangement deviates from the above in order to correspond with the arrangement of offices.

Section 3 is of open joist construction throughout; part is three stories high and the remainder two stories, all without basement. The 30x80-ft. three-story section joins the office building, while the 60x90-ft., two-story section is between it and the large four-story department known as section 4. This section is supplied by a 6-in. main from the pump room header, which is carried up to the first floor ceiling and longitudinally through this section with a number of risers from 2 to 4 in. in size to portions of the system on the second floor. A branch extends through the three-story section as a 4-in. feeder, where a 3½-in. riser supplies the two upper floors. A section of the first floor of the latter portion adjoining the street contains a shipping platform for the loading of wagons under cover, which is normally open to the outside, and there is a gate valve in the main supplying this exposed section, which will permit it to be cut out, and not be kept under pressure when there is possibility of freezing; yet the pressure may be quickly turned on the sprinkler heads at any time necessary. The longitudinal sprinkler supply lines are spaced 7 ft. apart on the average in this section, while the maximum sprinkler head spacing is the usual 8 ft., so that here each head covers less than 60 sq. ft. of floor area, and the staggered arrangement of heads is used throughout.

Sections 3 and 5 are old portions of the factory of light, open-joist construction, two stories in height, without basement, and each is supplied by a separate 6-in. main from the supply header in the pump room, with an arrangement of distribution mains and sprinkler piping similar to that in section 2. In both of these sections the longitudinal sprinkler lines are 7 to 8 ft. apart and the sprinklers are so spaced as to cover not over 65 sq. ft., the staggered arrangement of heads being used throughout.

Section 4 is the largest section. It is a 72x168-ft. building, consisting of a three-story and basement division 30 ft. wide, and a new addition 42 ft. in width, which has four stories and basement. This section is supplied by an 8-in. main from the pump room header, which divides in the basement into the two branch systems, one for either division of the structure. The system in each division is supplied through a 5-in. main extending longitudinally through its basement, from which a number of risers are carried to the upper floors. The distribution of sprinkler supply lines in the 30-ft. division, in which the usual type of open joists of construction is encountered, is similar to that of the other sections above referred to, each head covering from 40 to 60 sq. ft., while in the new division a very heavy type of mill construction was used, with 18-in. floor timbers of 20 ft. span, spaced 5 ft. center to center, supporting a flooring of 2-in. tongue and groove planking, which is covered by a 2-in. layer of asphalt and 1 in. of granolithic finish. Owing to the beam construction, the parallel arrangement of sprinkler heads was found convenient and they were installed on four lines of longitudinal piping about 10 ft. apart. The sprinkler heads are mounted upon these at 5 ft. spacings, with which arrangement the maximum floor area covered per head is 50 sq. ft.

The alarm system used in the sprinkler piping to give indication of the opening of the sprinkler heads consists of Evans circuit-closing valves in each supply main at the point of entrance to the section protected. These are a type of non-return check valve with inclined flap by which the entrance of water from the main to an auxiliary chamber is normally closed. In case of flow of water in the main, however, the flap opens and water is admitted to a variable pressure chamber and thence communicated to the circuit closer which has a diaphragm action closing a miniature knife switch. The variable pressure chamber is a time element between the valve and the diaphragm, to provide for changes in pressure in the system and possible leakage at the alarm check valve which might be effective in operating the circuit closer and causing a false alarm. It allows any leakage or slight flow due to sudden variations in pressure in the system to drain out and thus prevent a communication of pressure beneath the circuit-closer diaphragm, while a steady flow will quickly transmit sufficient pressure in excess of the drain capacity to cause an alarm.



Arrangement of Mixing Dampers and Ventilating Louvres.

The alarm circuits are carried from the various circuit closers to an annunciator in the pump room which indicates there the section of the factory in which opening of the sprinkler heads has occurred. A relay is connected with the annunciator system by means of which the closing of any alarm circuits will ring several large electric alarm bells, distributed in the pump room, office and other sections, and in addition will ring a gong in the particular section from which the alarm originates. The entire system of alarm circuits is fitted with testing connections permitting the batteries and various gongs to be tried from time to time. For emergency purposes, the pump room has two independent sources of lighting, the system involving groups of incandescent lights in the pump room and at the hose hydrants at the front and in the rear court of the buildings, which may be supplied either from the factory lighting plant or the street electric supply; a two-way switch in the pump room permits this emergency lighting to be thrown on either source of current supply so that in case of failure of the factory lighting system the lights may be kept burning from the outside source.

In the operation of the system the underwriters' pump is held normally in reserve and called upon only in case of fire. Pressure is maintained upon the sprinkler system by means of the 50,000-gal. elevated tank, which has an 8-in. connection to the pump room header, the various supply mains to the different sections of the factory being kept open. The connection from the pump to this header and also the suction connection from the pump to the service pipes from the street mains are kept closed. All valves in the pump room are sealed in their proper positions by official seals of the Underwriters' Association which must be broken in changing them, so that interference with the system is impossible without disturbance of the seals. In case of fire the delivery connection from the pump into the system, as well as the suction connection to the street mains, will be at once opened, and the pump started immediately. As the pressure in the city mains is 20 lb., the supply to the pump will be ordinarily taken from them in preference to the 100,000-gal. storage tank, although the latter will be instantly available in case of any shortage of the city supply. In addition to the above arrangement of connections, there is an extra precaution in a by-pass connection from the city water mains past the pump to the delivery header, which may, in case of the pump being out of commission, be opened to admit of the city pressure direct to the sprinkler system. As the street main pressure is raised during fires, this will aid the gravity tank.

The sprinkler system with tanks and tower, pumping and piping equipment and alarm system was installed by the International Sprinkler Co., Philadelphia, Pa. The Evans sprinkler head and check alarm valves were used, all heads having been set normally for fusing temperatures of 165° Fahr. Where higher temperatures are encountered in rooms, 212° or 280° Fahr. fusing links are used, the latter type being used on sprinklers under skylights.

Heating and Ventilating St. Paul's Hospital, Montreal.

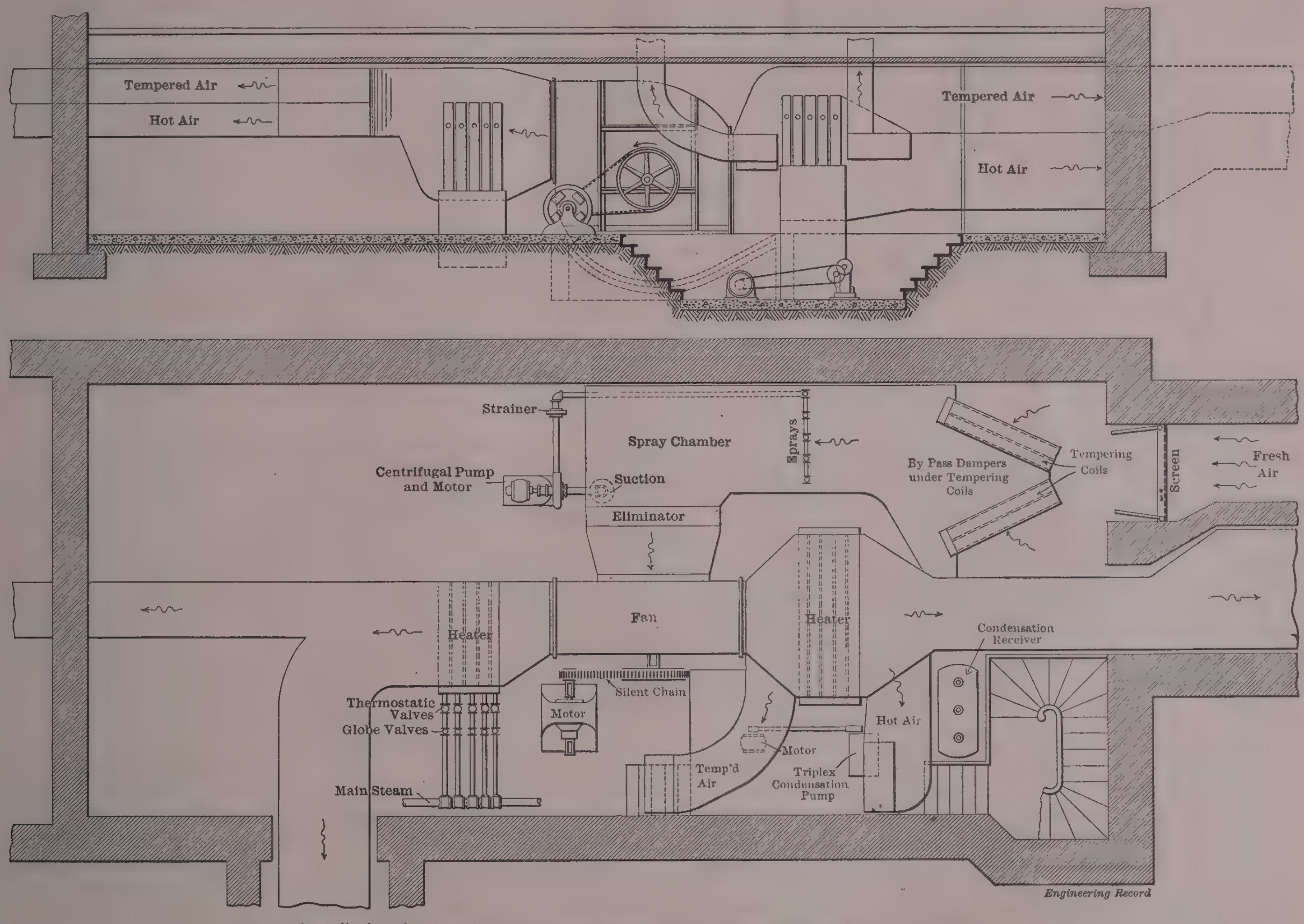
The heating and ventilating apparatus in St. Paul's Hospital, Montreal, consists of a motor-driven fan, tempering and heating coils, with their supply and return coils, ducts for the distribution of the air, deflectors for adjusting and dampers for controlling the currents of air, thermostats for the regulation of temperatures, and a combined air washer and humidifier for cleaning and moistening the air. The installation was described recently by Mr. Alan G. McAvity in a paper read before the Canadian Society of Civil Engineers, from which the following notes are taken. The fan is a three-quarter housing steel plate centrifugal with double discharge, driven by a direct-current motor by means of a chain drive. At full speed it delivers 45,000 cu. ft. of air per minute, and by a rheostat in the field circuit of the motor two lower running speeds may be used. The coils are of the mitre type, which are usually employed for hot water, as the resistance to circulation is very low, and in this case they are used with low pressure steam for the same reason. Tempering coils are placed between the inlet and sprays to bring the air at least above freezing point. A temperature of 50° to 55° Fahr. is found necessary in the spray chamber, because the temperature in this chamber affects the humidity, and because some air by-passes the heating stack on the discharge side of the fan, and, therefore, goes to the rooms without a further increase of temperature.

The distributing ducts beginning beyond each heating stack, carry separately, hot air which passes through the heating coils, and tempered air which goes above them. These ducts are kept separate until the mixing damper is reached, of which a detail is shown in one of the illustrations. In each duct there is a balanced damper, and the two are joined together by a link, so that when one is open the other is shut, and vice versa. Thus a constant volume of air is supplied at a temperature varying in such a way as to balance the heat losses from the building. In most rooms the dampers are controlled by thermostats, to give a constant temperature, but in some they are arranged for hand regulation.

The air washer and humidifier consists of a number of spray nozzles in a plane at right angles to the course of the air, and a box of baffle plates arranged herring-bone fashion to remove the dust and water carried mechanically. In the fan room of the hospital, space is valuable for every foot is below the ground level and excavation is expensive. If the cross-section of the dry box or eliminator is to be reduced, it is necessary to figure on a higher velocity of air in order to handle the same quantity. In this case a velocity of about 350 ft. per min. is used, and the loss in friction is so small as to be almost negligible. Considering that each baffle plate is but 2 in. long, and the total thickness of the box but 12 in., it seems impossible that the moisture can be completely removed. A piece of dry paper placed behind the box at any point will show no trace of drops of water, however, nor is there any perceptible moisture on the last bend of the plates. The first bends are purposely left without projection at the angles to allow a film of water to form, and it is this film which collects most of the moisture and all dust or soot. The first projection prevents most of this film from being carried through, and the remaining projections remove thoroughly whatever water may remain.

While dependence is placed on the film to remove all water carried mechanically, the moisture carried by absorption is, on the contrary, increased to an amount dependent chiefly on the velocity of the air through the space between the plates. At any given running speed of the fan this velocity is constant, and the relative humidity of air leaving the baffle plates at full speed remains nearly constant at 80 per cent., independent of the relative humidity of the entering air. If the temperature of the spray chamber is kept at 55°, each cubic foot will carry 80 per cent. of 4.85 grains or 3.88 grains of water, which will give a constant humidity of a little more than 55 per cent. when the air is warmed to 65°. The temperature in the spray chamber is kept constant by a thermostat, which operates a by-pass damper below the tempering coils, admitting enough cold air to reduce the temperature as required. The air in the tempered air ducts will remain at 80 per cent humidity, and the air in the hot air ducts will enter the room at a low relative humidity, but in either duct 3.88 grains are carried by each cubic foot of air, which corresponds at 65 degrees to a humidity of 55 per cent., and if the rooms are kept at this temperature the humidity will be practically constant.

Both hot and tempered air ducts are made of galvanized iron of the following gauges: All pipes of less than 5 ft. circumference, No. 26 gauge; 5 to 8 ft. circumference, No. 24 gauge; 8 to 10½ ft. circumference, No. 22 gauge; 10½ to 13¼ ft. circumference, No. 20 gauge; 13¼ to 19 ft. circumference, No. 18 gauge; above 19



Installation for Heating and Ventilating St. Paul's Hospital Buildings in Montreal.

ft. circumference, No. 16 gauge has been used.

The cross-section at any point of the air ducts is designed to give a constant friction per foot of length, and each branch is designed to receive its proportionate supply, though the amount of air it receives will depend largely upon the angle at which it leaves the main duct, and at this point a deflector is installed to permit careful adjustment when taking an anemometer test.

There are four separate buildings to be heated, and the ducts run through tunnels to three of them. Hot and tempered air are carried in separate ducts from the coils and by-pass until close to the opening into each room, where mixing dampers are located as shown in accompanying detail drawing. As soon as possible after passing the dampers a gradual increase of 50 per cent. in the area of the duct is made, which makes the velocity of air entering so low that there is no perceptible draft. No register faces are used, but the iron of the duct is flanged back against the wall and covered with a plain wood border. This arrangement gives a neat appearance, and by doing away with registers gives ready access for cleaning, and an unobstructed flow of air.

The vent flues all have dampers, which are, in most cases, kept partly closed to ensure a slight plenum in the rooms. All vent flues lead to the attic, in which there are two ventilating towers with movable louvres. The louvres are made of a waterproof silk, with a rod at top and bottom to keep its shape. The top rod is stationary in a frame, and the bottom rod is light enough to allow air to escape, but heavy enough to fall back in place if there is a tendency for air to enter.

It is noticeable that in such a ventilating system there are many adjustments to be made, but most of these are made when testing, and are then left permanently in a fixed position. After all deflectors and dampers are set no change can be made in the amount of air supplied, except by varying the speed of the fan, and this can only be done from the switchboard. Thermostatic dampers in most rooms keep the temperature variation within one degree. Another set of thermostats placed in the fresh air inlet are adjusted to close off one coil of the heating stacks at 10° above zero, a second at 20°, and a third at 30°. Similarly one section of the tempering coils closes when the out-door temperature is 35°, and the other closes at 60°. The temperature regulation is thus taken care of, and since, as already explained, the humidity is controlled automatically, the only attendance that is required is the occasional cleaning and oiling of motor, fan and pumps.

The operating expense and first cost of such a system of heating and ventilation will be higher than for a system of direct steam piping designed for heating alone. While accurate data for comparison are not available, an examination of the formulæ will show the reason for the difference found in practice.

A common formula for the loss of heat from a building is $H = (nc/55 + K\ G + k\ W)\ t$ where H = loss of heat in B.t.u. per hour, n = number of times air is changed per hour, c = cubical contents of building in cubic feet, G = area of exposed glass surface in square feet, W = area of exposed wall surface in square feet, t = difference of temperature between air inside and air out of doors, K and k = coefficients for the loss of heat in B.t.u. per square foot per hour through glass and wall respectively.

An average value of K is 1, and of k ¼, so that a general formula would be, $H = (nc/55 + G + \frac{1}{4}W)\ t$.

In this formula $(G + \frac{1}{4}\ W)\ t$ expresses the heat lost by radiation through walls and windows. This loss would be the same for either a direct steam system or an indirect heating system if the temperature in the room were uniform. To heat a building satisfactorily with direct steam it is necessary to place much of the radiating surface along outside walls. As the air back of and above these coils or radiators will be hotter than air in the body of the room, the loss by conduction is proportionately increased. Obviously, with an indirect system there is a saving, as the hot air pipes are carried on inside walls and the temperature is practically uniform.

The expression $nct/55$ is an allowance for the heat required to warm air which enters around doors and windows and through the walls. In a building 50 ft. high, with an indoor temperature of 70° in zero weather, there would be a pressure inwards against the wall at the ground level of about one-half pound per square foot. Through openings at top and bottom, air, with a free passage, would flow at a velocity of over 3,000 ft. per min. The friction of the course that such a current of air takes in an ordinary building reduces the above figures, but in any room, if the upper sash of a window is lowered, and the lower sash raised, air will flow in at the bottom and out at the top at a comparatively high velocity. When the sashes are shut air still comes in through crevices, and through the walls, and, unless the construction is exceptionally tight, unpleasant cold drafts will be formed.

The volume af air which thus passes through the building by filtration must be heated to the temperature maintained. An estimate of the volume which is to be heated must be made, and with proper allowance for the nature of the construction the value of n (the number of air changes per hour) is for corridors, 3; for churches and assembly rooms, 2 to 2½; for ground floor rooms, 2 to 3; and for second floor rooms, 1½ to 2.

With an indirect system of heating the expression $nct/55$ gives the British thermal units required for ventilation alone. With a direct steam heating system the infiltration of air might be considered as ventilation, but the amount is uncertain and inadequate, and any advantage of ventilation received is more than offset by the injurious effect of the drafts formed. With an indirect system all entering air is heated before it goes to the rooms, and there is no leakage around doors and windows, for a plenum is formed by the fan, which reverses the natural tendency and causes an outward flow of air. If the fan were to take its supply of air back from the rooms no plenum would be formed, and there would be an infiltration of air as with direct steam heating. If part air is taken from out of doors and part returned there is a proportion at which, if a window is opened on a still day, no perceptible flow of air will take place in either direction. This is the condition when the same amount of air is taken from out of doors as would otherwise enter by filtration. When so operated, although ventilation to the extent of about two air changes per hour is supplied, the cost of operation will be a minimum, and will be the same as for direct steam heating.

A supply of two air changes per hour is not sufficient for a hospital, and the fan takes its entire supply of air from out of doors, giving an air change in from 6 to 8 minutes, or eight to ten air changes per hour.

The cost of fuel for ventilation alone may be easily estimated. Assuming an average temperature of 30° from Dec. 1 to March 1, the coal required to supply 3,000 cu. ft. of air per capita per hour can be calculated from the formula $H = nct/55$ to be 1636 British thermal units per hour. In a hospital ventilation is supplied day and night, giving a total requirement of 3,533,760 British thermal units per capita for three months. Assuming an evaporation of nine pounds of steam per pound of coal, the coal required during the three months stated would be about 450 lb. per capita.

The Prevention of Smoke.

Condensed from an address by Albert A. Cary before the New York Section of the Society of Chemical Industry.

If the mere matter of the abatement of a nuisance was all that would be attained by the suppression of smoke, city governments would find their progress in enforcing preventative ordinances very slow and unsatisfactory; but when it is generally understood that a very decided economy in fuel will follow the suppression of smoke, fuel economizers may be led to take another view of this matter and find that such ordinances are really a blessing in disguise. Some people have a very crude idea of this subject, and think that the economy would be derived from the consumption of the small particles of soot and tarry matter sent out of their chimney. This is not a fact as tests have shown that the economy derived from the entire consumption of such rejected matter would be trifling. The true facts are that a smoky chimney indicates conditions of improper fuel handling in the furnaces, resulting in a falling off of fuel economy many, many times greater than the loss resulting from unconsumed, rejected solid matter.

During the course of his professional work, Mr. Cary was brought into communication with the smoke commissions of several cities and, having studied the subject of smoke ordinances, he was led to make the following suggestions to one of these smoke commissions. These, when properly enforced, would bring about the desired results, in his opinion.

"While you are dealing with the smoke question why do you not take up the matter of high standard requirements for firemen? If all plants using boilers were obliged to employ firemen of considerable intelligence there would be less trouble than when a lower grade of men are employed. Could not the firemen be required to pass examinations requiring a certain amount of knowledge on the subject of boiler furnace manipulation? By raising the standard of qualification you would necessarily bring into service a class of men commanding more pay than those ordinarily employed, and as no plant could be operated without a licensed fireman you would have in your hands a weapon of considerable power. In case any plant became a persistent smoke offender, you could first warn the fireman in charge, and then if this was not effective, finally cancel his license. This action need not prevent the fireman from obtaining a job in another place, although it would require him to stand another examination and take out a new license. In case such a man had his license concelled three or four times, the Board of Examiners could refuse to give him any further authority to act as fireman.

"Should two or three firemen be successively deprived of their licenses in a plant, it would be a pretty difficult matter to get a licensed fireman to operate the boilers, as they would know that, with the conditions there, it would only be a short time before their licenses would be revoked. The consequence would be that the offending plant would be obliged to cease operations, as the owner would be unable to obtain licensed firemen to operate it, and such action would eventually force him to take measures to suppress the smoke nuisance without further delay."

In framing smoke ordinances it is necessary to find what degree of density of smoke constitutes an offence, and it will be found that with such a definition a certain amount of latitude must be allowed to prevent an unreasonable infliction upon the consumers of fuel. There are periods of two or three minutes during the course of firing when a slightly greater density of smoke will be emitted from the chimney than that defined by the ordinance; therefore it is well to state that smoke above a certain degree of density will not be permitted for periods of over two or three minutes, and during the course of such periods smoke of a somewhat greater defined density may issue from the chimney.

The best-known method of determining the density of smoke is by the Ringelman chart, which is composed of six squares, the first being perfectly white and the sixth entirely black, while the intermediate squares have each a series of black lines ruled upon them at fixed distances apart and differing in thickness. This chart is placed between the observer and the chimney to be observed, and at a distance the ruled lines on the chart are blended together in such a manner as to form a succession of tints so that the observer may compare the tint of the chart to the gray or black coloring which issues from the chimney.

In making smoke observations the use of this chart has at times been extremely inconvenient on account of the fact that it must be placed some 60 ft. away from the observer in order to get a proper blending of the black lines. In order to overcome this difficulty the late Bryan Donkin produced a chart consisting also of six squares, the first being white and the sixth being black, the same as with the Ringelman chart, while the squares placed between these two extremes consist of series of flat tints of gray produced by a photometric process and ranging by definite steps from white to absolutely black. An observer can hold it a foot or two away from his eyes and compare the shades or tints of gray with the smoke issuing from the chimney and may thus easily decide upon the degree of smoke density issuing from the chimney.

Smoke depression depends upon, first, intelligence in the boiler room; second, proper design of the grate; third, proper design of the furnace.

Intelligence in the Boiler Room.—In considering the problem of smokeless combustion no matter should receive great attention than the selection of firemen. It remains for the steam plant owner to decide whether he will pay low wages and high fuel and repair bills, or pay a good price to his fireman and more than make up the difference by reduced fuel and repair bills, and, further, be able to count on a constant supply of steam at a uniform pressure.

Automatic stokers require in their operation fully as much and sometime more intelligence than does a plain grate bar furnace properly operated, and many times Mr. Cary has seen such apparatus condemned in plants where their failure to work properly was wholly due to improper handling by ignorant firemen.

A good fireman should possess a rudimentary knowledge of the principles of combustion. Such knowledge would in most cases necessarily be more of a practical than of a theoretical nature. The fireman should further be able to demonstrate his ability to put such knowledge to good use by firing skillfully, placing every shovelful of coal where it will give the best results; promptly filling every hole in the fire bed through which cold air is rushing; keeping his fuel bed level and even throughout; keeping his fire box temperature up to a desirable degree by skillful manipulation of furnace doors, ash pit doors and damper; by avoiding unnecessary slicing but at the same time keeping his fuel bed sufficiently open for the free and even passage of air. He should also be able to tell very nearly the condition of his fire by watching the appearance of his ash pit. He certainly should understand the construction and operation of every piece of apparatus used in connection with his boiler, including feed pump, injector, valves, water columns, steam gauges and every other appurtenance, and be mechanic enough to repair them, especially when emergencies arise.

Grate Surface.—The grate and the furnace should each receive careful consideration by themselves in order to obtain smokelessness and good economy in fuel.

One of the most important matters concerning the grate is to obtain the proper area of surface to burn the fuel used to the best advantage. The particular kind of coal to be used should first be selected and then the rate of combustion per square foot of grate per hour should be decided upon, and the rate of combustion per square foot of surface per hour at which this particular coal can be burned with the best results should be considered in designing the grate area. The area of the grate may be too large, but more frequently we find it too small, which causes a forced condition of firing, producing smoke and low efficiency. This matter of insufficient grate area is probably one of the principal reasons for smoky chimneys in the large plants of New York.

It will be found that different coals have different rates of combustion to secure the best and most smokeless results, and after going over many tests conducted by himself and tests conducted by others in whom he places confidence, Mr. Cary finds that the following rates of combustion for boilers developing their rated horsepower have proved to be good practice: Anthracite, 15 lb. per square foot of grate surface; semi-anthracite, 16 lb.; semi-bituminous, 18 lb.; Eastern bituminous, 20 lb.; Western bituminous 30 lb. The anthracite and semi-anthracite are steam sizes.

The reason for this increased rate of combustion from the anthracite to the Western bituminous is that each coal in the order named contains an increased amount of volatile matter.

The fixed carbon contained in the coal is burned directly upon the grate into CO and CO_2, while the volatile matter is distilled off from the coal and rises into the combustion chamber above and beyond the furnace, where it is consumed. The amount of fixed carbon burned per square foot of grate per hour increases slightly as the volatile matter increases, but the increase is not great. These figures are only approximate, as there are other conditions which enter in this problem, such as the available draft, the percentage of ash and percentage of sulphur contained in the coal.

An important matter in grate design is the proper proportioning of the space between the bars, which space in the bars must be of ample width to allow sufficient air to pass to the fuel bed and combustion chamber beyond it. Where an excessive amount of ash occurs in the fuel used shaking instead of plain grates should be used, so as to keep the air openings at the top of the grate clear of ash and thereby facilitate the free passage of air.

The grates used in mechanical stokers are supposed to accomplish this result by more or less constant movement. Too enthusiastic salesmen of mechanical stokers having inclined grates have been inclined to convey the impression that the grate area is enlarged in proportion to the difference in the length of the hypothenuse of the angle formed by their inclined grates as compared with the base, measured from the bridgewall to the front of the boiler in the ash pit of the furnace. Such claims should not be considered, as by examining the working of furnaces it will be found that the upper part of the grate is inactive owing to the coking of the coal occurring at that position without actual combustion occurring, and also owing to the length of the ash bed which forms at the lower part of the grate bars. Therefore, the area of the grate should not be considered as anything more than the area of a flat grate fitted into the same furnace.

The length of a grate bar for hand firing should not be over 6 ft., as deeper furnaces cannot be properly manipulated by the average fireman; but the length provided for mechanical stokers with inclined grates may be extended some 20 per cent., as the automatic method of working should properly take care of this additional length.

Care should also be taken in providing large ash pits under the grates of deep furnaces in order to allow the air to properly penetrate to the rear part of the furnace and supply the back part of the fuel bed.

Furnace Design.—Furnace design is of extreme importance, especially in coals carrying over 15 per cent. of volatile matter, as the combustion of the volatile matter in coal is a two-step process which consists, first, in distilling off these gases from the coal as they come in contact with the incandescent fire bed and, second, in their combustion in the furnace chamber above or beyond the fuel bed.

These volatile gases are the smoke producers, and the smokelessness of the furnace depends entirely upon the manner in which their contained carbon is burned. The gases composing this volatile matter have a certain temperature of ignition, and when that temperature is reached they will ignite and burn. As their temperature drops below the ignition temperature, we have, first, a state of incomplete combustion, and finally, as the temperature drops still further, we have a condition of almost entirely arrested combustion. Therefore, in order to obtain smokelessness we must constantly maintain a temperature in the combustion chamber above 1,400° Fahr., and we must also have a combustion chamber of sufficient size to receive these volatile gases and burn them completely before they strike the colder boiler surfaces where they are generally extinguished.

The larger percentage of volatile matter, the larger these combustion chambers must be made, and if we wish to secure a high degree of economy we must entirely complete our combustion of these volatile gases before delivering them to the boiler, or other chilling surface beyond the furnace.

This condition is best attained by enclosing the top of the combustion chamber with a firebrick arch, which becomes highly heated during operation and gives off sufficient heat to hasten the process of combustion, and means should also be provided to thoroughly intermix the air with the gases distilled from the coal.

Scientific Methods of Hand Firing.—There are three methods for hand stoking a boiler furnace to produce the best results from both an economical and a smoke-suppressing standpoint. These are commonly known as "coke firing," "alternate firing" and "spread firing," or perhaps a more correct name for this last named method would be sprinkle firing. Some bituminous coals will produce better results by the use of one method, while other coals may not be as well adapted to this one as to one of the other methods. This is largely due to the behavior of the coal when it is heated.

Some bituminous coals will exhibit little or no coking or fusing quality, but will tend to disintegrate when heated and fall into a more or less loose powdery form. Such coal will not stand much moving about on the grate after it has once been charged into the furnace. Such movement causes it to scatter, when some of it is apt to be lost either by falling through the grate bars unconsumed, or, in cases where considerable draft pressure exists, by being carried along with the products of combustion into the rear of the boiler setting. At the other extreme we find coals which, when heated, will swell up and fuse into a coherent mass, forming a crust on top of the fire bed, but after the volatile matter has been distilled off from such coal the cake can be broken and easily moved about to any desired position on the grate bars. If two such extreme coals can bt obtained at one time they can often be mixed in proper proportions (determined by experiment) and used to much better advantage than when either is used alone.

It will be found that nearly all of the special furnaces and stokers depend more or less upon some one of these methods for their required system of firing, thereby in most cases allowing them to be classified under one of these three heads.

Coke Firing.—The coking system of firing is mainly applicable to furnaces delivering their gases over a bridge wall at the rear of the furnace or else those running their gases back to or nearly to the rear of the furnace by use of a brick arch forming a roof some distance above the fire bed.

In such a furnace assume that we have a hot bed of coal which has distilled off most of its hydrocarbonaceous matter, practically a bed of coke, which burns smokelessly. On charging fresh coal into the furnace, instead of throwing it directly on this fire bed, we pile it just inside the door, back of the dead plate, allowing it to occupy one-third of the length of the grate, more or less, and extending it across the width of the furnace from one side to the other. A slow distilling of the volatile matter from the fresh coal pile will then follow, and these hydrocarbon gases must next flow over the incandescent bed of coke, through which flows an excess of air, highly heated in its passage, and as the air and gases are thus mingled at a high temperature perfect combustion should follow.

After most of the volatile gases have been distilled off from the pile of coal, the fireman pushes this newly formed coke back upon the grates and this forms a renewed bed of practically smokeless fuel, and he then charges a fresh supply of coal in a similar pile across the front of the furnace.

After the fireman gets accustomed to this method of firing and familiarizes himself with the behavior of the coal thus handled with a properly designed furnace, he will succeed in obtaining practically smokeless results, and he will find this method no more difficult to follow than any other rational one. From an economical standpoint varying results will be obtained, but generally a saving of fuel will result; in some cases as high as 10 per cent. saving has been shown as compared with the ordinary irrational methods of firing.

The principal disadvantages of this method are the length of time it is necessary to keep the firing doors open for charging and for cleaning. At such times a large amount of cold outside air rushes through the furnace, not only checking complete combustion, but also producing strains in the boiler parts more or less harmful. This can be practically counterbalanced by closing the damper at such times, but cleaning a fire with a closed damper throws the dust and gases back into the boiler room, making it a dirty malodorous place, and few firemen enjoy such cleaning with closed damper. Sometimes the damper is but partially closed as a compromise between these two troubles.

By continually shoving back from the front of the furnace the coked coal, which, of course, carries in it all the ash, this ash accumulates in the least accessible part of the furnace, i. e., the rear, which not only increases the work of cleaning, but makes it a longer operation, the furnace door being wide open all the time.

In order to overcome the necessity of having the doors open during so great a part of the time, an inclined grate mechanical stoker has been devised, which receives its fresh coal in a hopper placed just outside of the furnace, and by mechanical methods feeds it automatically to the upper end of the grates, next working this coal as fast as it cokes down the grate towards the bottom of the furnace, and when reaching this lower position the remaining ash reaches a dumping section of the grate from whence it is removed either continuously or periodically by operating mechanism provided for the purpose.

Inclined grate stokers have two methods of feeding their coal to the furnace, first, from the front towards the rear, and second, from the sides towards the center of the furnace. Where wide furnaces are found, having but (comparatively speaking) little depth (i. e., between the furnace front and bridge wall) the front feed furnace is especially adapted, but in furnaces where the greatest dimension of grate area is found in the depth (as compared with the width) the side feed furnace is preferable, especially in coals running over 25 per cent. in volatile matter. Nearly all of the volatile matter should be distilled from the coal before it begins to descend the inclined grates, which allows a bed of incandescent coke (producing practically no smoke) to exist in the center of the furnace and the heat from this incandescent coke bed must be relied upon to distill the gases from the fresh coal, which is constantly being pushed from the hoppers on to the coking plate at the top of the inclined grates. With a short coking plate, coal must be moved very rapidly into the boiler furnace to supply sufficient fuel to produce the required evaporation, and a very rapid distillation of the volatile gases must take place to produce a coke at the top of the inclined grates. This rapid distillation is rendered all the more difficult by having the incandescent coke bed extend a considerable distance away from the coking plate. Should we double the length of this coking plate (for the same amount of fuel fed) we will allow twice the length of time to distill the volatile gases and at the same time, we will bring the highly heated coke bed very much nearer to the green coal. Experience shows that the further the green or partially coked coal extends down the inclined grate, the greater is the amount of smoke produced, and the lower the economy of the furnace becomes.

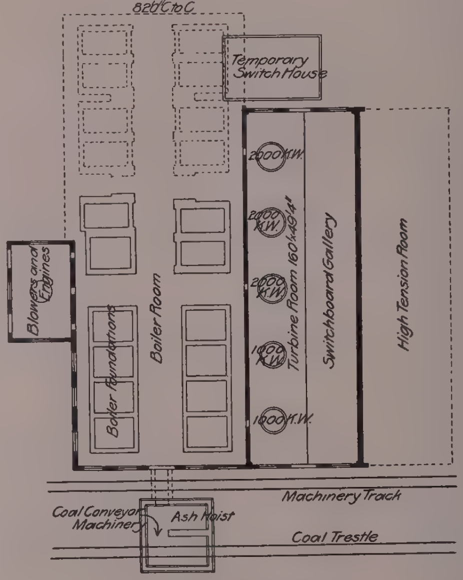
Another method of smoke suppression is a washing method by which the small particles of carbon and tarry matter as well as the floating particles of ash are washed out of the products of combustion while they pass through a spraying chamber on their way to a chimney. In some cases the chimney itself has a spray of water located over its top so as to wet the rising particles of solid matter and carry them thus weighted with moisture to the bottom of the chimney, where this soot-laden water is discharged to the sewer or some settling tank from which place the resultant is taken and by-products may be recovered. These products include gas tar, etc., fixed carbon and sulphur. Any washing or filtering process for smoky gases is a very unsatisfactory method of getting rid of this troublesome matter.

The Construction of the Utica Station of the Hudson River Electric Co.

By Willard M. Foster, Resident Engineer.

Early in April, 1905, work was begun, under the direction of Mr. C. E. Parsons, chief engineer of the Hudson River Electric Power Co., on the construction of a steam power plant at Utica, located just north of the New York Central R. R., on what is known as the Deerfield Flats, about one-half mile west of the railroad station. At the time of commencing operations the lot was covered with water from the spring floods.

Reference to the accompanying plan shows the arrangement of the station. The turbine room is 162 ft. by 51 ft. 4 in. on the center lines of the walls, in which are located foundations for two 1,000-kw. Curtis steam turbo-generators and three of 2,000 kw. each, with the condensing apparatus, switch and bus bar compartments, and switchboard gallery on which will be placed the switchboard, rotary converters, etc. The boiler room has one portion of 105 ft. 4½ in. by 78 ft. 8 in., and another of 101 ft. by 82 ft. The blower room is 44 ft. 9 in. by 28 ft. 8 in.; the coal conveyor house, 30 ft. 6 in. by 30 ft. 8 in., and the temporary switchhouse is 30 ft. by 55 ft., and at the Mohawk River, about 900 ft. north of the station, there is the pump house, 25 x 40 ft., in which are three 16-in. centrifugal pumps, for supplying boilers and condensers. Connecting the station and pump house is a 36-in. pipe line.



Plan of Utica Power Station.

The lower floor level is approximately at the same elevation as the surface of the ground, and on this floor were built the foundation walls, 9 ft. high, for the building, boilers, blowers and steam turbines. This 9-ft. wall will surround the entire building, and as there are no openings through it, there will be no danger from high water.

There were required for the foundations to be used first, 1,500 30-ft. piles of 3,000 cu. yd. of earth excavation, 6,600 cu. yd. of railroad embankment, and 3,600 cu. yd. of Portland cement concrete.

Pile driving began on April 15 and the laying of concrete on May 1. As soon as the lower floor level was laid, the boiler and turbine foundations were started, and in the latter part of May the boilers and turbines were being installed. About this time work was begun on the pump house and pipe line. This last is of steel, 3 ft. in diameter, and about 1,800 ft. were used for supply and discharge lines.

For the generating equipment there were installed temporarily four Curtis steam turbo-generators of 500 kw. each (two direct-current and two alternating-current machines) furnished by the General Electric Co., of Schenectady. As soon as these were in place, a temporary wooden building was put up to protect them from the weather, and a shelter was built over the boilers, as shown in one of the illustrations. On July 1, seventy-five days after pile driving was started, current was furnished to the Utica & Mohawk Valley Ry. Co., steam being generated from a battery of four 500-h.-p., water-tube boilers, built by the Franklin Boiler Works, of Troy, N. Y.

The remaining columns for the frame of the building were now set up, and the concrete walls built. Brickwork having been started in August, the outer walls of the buildings were nearly completed on December 1.

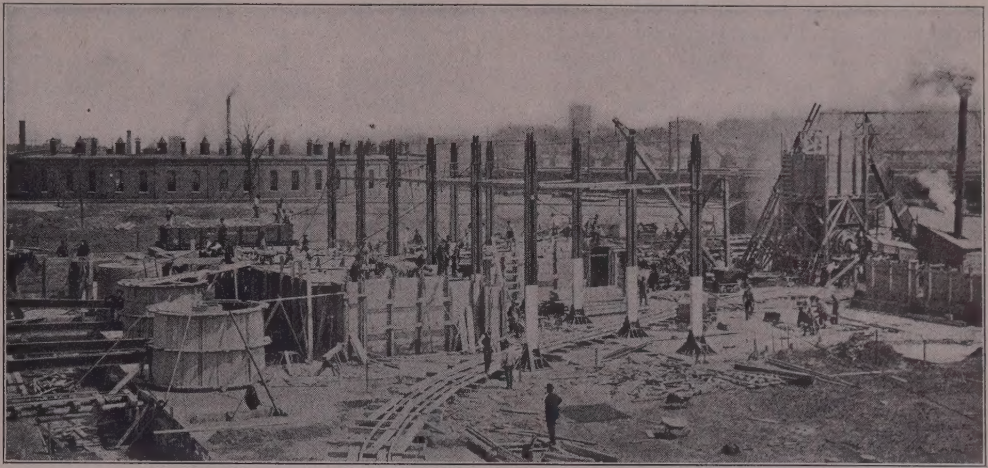
In August it was found necessary to install another 500-kw. machine, and piling was driven for this foundation, which was ready for the turbine in 12 days' time from the receipt of the order to put it in.

A 25-ton electric crane is located in the turbine room for handling material, and at the present writing, Jan. 30, is being used to install the first of the 2,000-kw. machines.

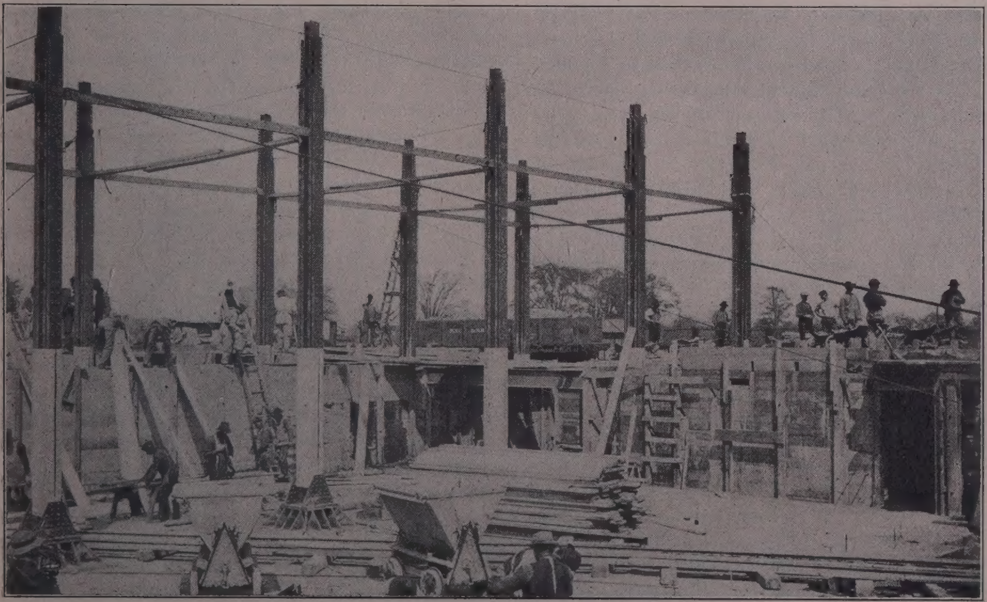
Under the tracks in the coal house is located the coal crusher and conveyor machinery, and coal is carried to the bunkers above the boilers. As the boiler house is extended, additional coal bunkers will be provided. Ashes are conveyed from ash pits in a car to the ash hoist located in the coal house, and hoisted into a car on the railroad for removal.

At this time, Jan. 30, there are in commission ten boilers of 500 h.-p. each, and foundations for five more sets of 500 h.-p. each are being prepared; the ultimate boiler capacity being 10,000 h.-p.

The piling, excavation and concrete work to Jan. 1, 1906, were as follows: Number of piles driven, 2,700; earth excavation, 4,200 cu. yd.; concrete in foundations, 5,900 cu. yd.; concrete in roofs, 250 cu. yd.; and brick for walls of building, 930,000.



View of Utica Power Plant taken May 24, Showing Three Turbine Bases and Part of Boiler Foundations.



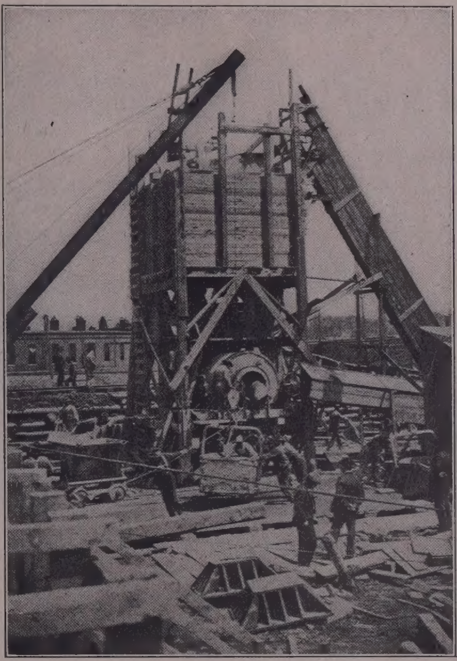
View of Utica Power Plant taken May 24, Showing Boiler Foundations and Post Supports.

The Lift-Lock Troubles at Peterboro, on the Trent Canal, have been greatly exaggerated. According to the secretary of the Canadian Department of Railways and Canals, there has been no trouble to the famous lift-lock proper, but some leaks have developed in the embankment approaches to it.

The Farwell, Ozmun & Kirk Co. Warehouse at St. Paul.

By W. H. Dillon.

This building, which shows how rapidly the Northwest is coming to the front in fireproof construction, has nine floors, and is 120 ft. high, covers about an acre, being irregular in shape with no sides parallel. It is 260 ft. long on the north side and 150 ft. facing the east on Jackson St. The south side, which is facing the Mississippi River, has a wagon entrance at the east into a driveway of 32 ft. clear width running the full width of the building, and also an entrance into the building for freight cars with a double track extending 200 ft. along the south side. Being built on the side of a bluff, the excavating and building of retaining walls took about three months before the reinforced concrete, of which the interior wall and column footings, columns, beams, floor and roof are built, could be started. About 35,000 cu. yd. of clay and gravel had to be hauled away from the site.



Concrete Mixing Plant.

The building was originally designed for slow-burning construction, but when the owners learned that it could be made fireproof at an additional cost of about 7½ per cent. above the slow-burning construction, they adopted the Kahn system after investigating the best fireproof forms of construction. The first three floors are designed to carry a live load of 500 lb. per square foot, the fourth, fifth, sixth and seventh floors, 350 lb.; the eighth floor, 250 lb., and the ninth floor, 200 lb. per square foot.

The interior wall footings were originally designed of plain concrete, but were changed to reinforced concrete when it was found that 3 ft. of excavating, amounting to 5,000 cu. yd., could be saved. The average column footings are 11½ ft. square with a depth of only 4 ft. 2 in. below the finished first floor level. In order to keep the size of the columns a minimum, I beams were used for reinforcing the first and second-story columns, channels with batten plates were used in the third, fourth, fifth, sixth and seventh stories and Kahn trussed bars in the eighth and ninth stories. The concrete columns start on the first floor 20 in. square and reduce 2 in. every two stories until the roof is reached. Of the 143 columns, all but two start at the ground on reinforced concrete footings.

Work was begun putting in the column footings on April 1, 1905. On June 1, 1905, work was started on the columns and floor of the west section and from then to the time the roof was completed, Nov. 27, 1905, the work was carried on at the rate of an acre and a half of floor, including columns and beams, per month. The work was greatly facilitated by the use of iron beam clamps, which saved both time and labor in building and removing the wooden forms. These beam clamps held the beam boxes securely together, supported the joists for the floors and at the same time supported the whole falsework without the use of nails. In the alley near the center of the north side of the building the grade is about 6 ft. above the level of the third floor. This grade was utilized for handling crushed stone and sand to be used in manufacturing the concrete. A dump was constructed with chutes running to the first floor through which the materials were carried to the mixers, which were located on that floor. The cement was shipped into the building in cars over the switches which were laid as soon as the centering in that portion of the building was removed.

One hoist was located in a stair well at the west division wall and supplied with power from a 20-h.-p. motor. The other hoist was located in an elevator shaft at the east division wall and run with a 12-h.-p. motor. A Smith concrete mixer was set at each hoist to dump into a chute which carried the concrete into the boot of the hoist. The crushed stone and sand was measured in wheelbarrows and dumped directly into the mixers from the platform. The cement was emptied from the sacks into the mixers. Special 4-ft. wheelbarrows were made for handling the concrete, and such a system was organized that a maximum of 155 cu. yd. of concrete was placed in a 10-hour day.

A small sawmill was set up on the first floor and run with a motor to cut the lumber ready to be put into place for the concrete forms. This reduced the hand sawing to a minimum. Columns and beam boxes were all framed ready to set into place as soon as the floor below was completed. Four-inch by four-inch posts were used for supports in conjunction with the beam clamps and no diagonal braces were required. Typical floor panels are 13 x 16 ft. The span over the driveway is 32 ft. and that over the tracks 16 ft. In nearly all the beams and girders three Kahn bars were used, lapping through the columns and over the beams, being reinforced with inverted 5-ft. Kahn bars running through all the columns from girder and beam to beam.

The floor slabs designed to carry 500 lb. per square foot are 6 in. thick, the other floor slabs and the roof where the span does not exceed 13 ft., are 4½ in. thick. The roof slab with spans greater than 13 ft. is 6 in. thick and reinforced with bars on 16-in. centers running across the panels in both directions. All panels of the roof are provided with temperature bars. The floor slabs are reinforced with ½-in. Kahn bars placed 9 in. on centers in lengths to reach over two beams, the alternate bars breaking joints.

The floors designed for 500 lb. per square foot were tested at the age of thirty days. One entire panel loaded with that unit weight and allowed to stand four days was without a particle of deflection. At the age of ninety days the center half of a panel next to one of the walls was loaded to 770 lb. per square foot, and allowed to stand four days, with no resulting deflection. Then 730 lb. per square foot were added, making 1,500 lb. per square foot, which produced 1/64 in. deflection. This load was allowed to remain four days longer, but no further deflection occurred.

Thirty thousand barrels of Marquette cement, 15,000 cu. yd. of crushed stone and 8,000 cu. yd. of sand were used. The structural steel, over one thousand tons of which was used in this construction, was furnished by the St. Paul Foundry Co. The lower three floors have finish coat of cement and the remainder have maple floors and finish. The floors required 240,000 ft. of 3-in. factory flooring, and 18,000 ft. of maple flooring, and was furnished to the architects satisfactorily by the John C. Hill Lumber Co., of St. Paul.

In providing for the reception and discharge of freight an interesting problem in engineering was solved. The railway tracks, of which there are two, enter the building on a 16-degree curve accommodating the unloading of ten cars at once, and necessitating a very large opening. This is spanned by a box girder of extraordinary size, the span being 42 ft. in the clear, weighing 35 tons, and supporting about 800 tons. This was supplied by the St. Paul Foundry Co. Another similar feature is the 32-ft. driveway the entire width of the building, which is also spanned by heavy trusses, giving a clear space for the passage of wagons in shipping.

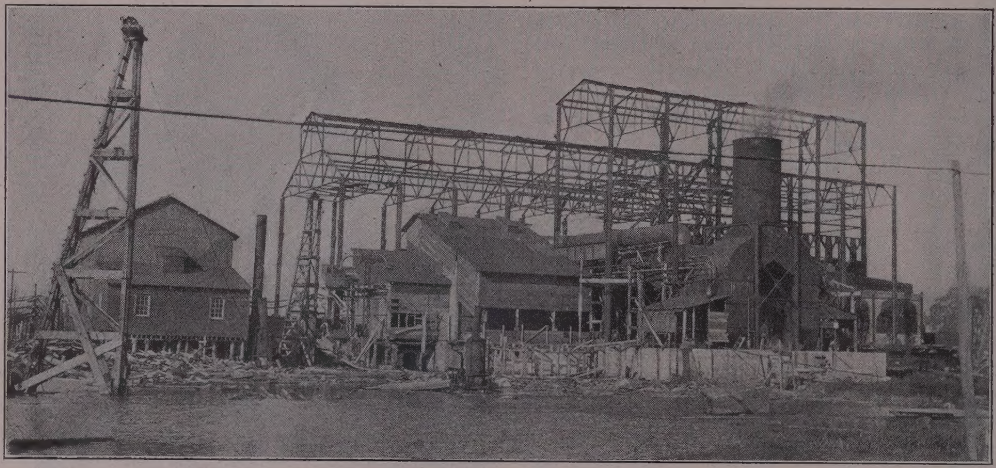
The equipment of the structure is in every way complete for convenience, fire prevention and fire protection. There are four high-speed freight elevators with 8x10-ft. platforms; there is one rapid high-powered elevator with 6x8-ft. platform; one passenger elevator running from top to bottom, and another from fourth to fifth floors. There is also an electric dummy operated for city business entirely. These elevators are all electric and were all designed and installed by the Lee & Hoff Manufacturing Co. They are all enclosed in brick shafts. The stairways, which are separate from the elevators, are enclosed in brick, the treads being of concrete. The doors closing the railway and driveway entrances, the latter being 17 x 23 ft. in size, are of the Kinnear steel rolling pattern. Though the extreme size and location of these doors might be expected to make them difficult to handle, their construction is such that they close the opening perfectly and are easily operated. Double fireproof doors supplied by the Variety Manufacturing Co., of Chicago, are installed at all openings in the two fire-walls, and are supplied with fusible links connected with weights for automatic closing. The complete system of ventilation was designed and installed by the B. F. Sturtevant Co., of Boston.

The steam for the heating system is supplied by the Northern Manufacturing Co., but the boilers of the warehouse, used for other purposes, are connected to the heating apparatus and there is sufficient room for an increase of boiler capacity arranged for the owners to supply their own steam.

While the building is as near fireproof as material and its scientific application can make it, an elaborate sprinkler system has been installed throughout. The floors are constructed in an incline with automatic scuppers in the walls to carry off water when the sprinklers are in operation. The water for this and other purposes is supplied by an artesian well 370 ft. deep below the foundations and the water is pumped to tanks on the top of the building. The window frames are of metal on two sides of the structure and these windows are filled with wire glass as a protection against adjacent fires. Two fire escapes are also installed on convenient points. The structure is covered with a five-ply gravel roof.

As a complete exposition of the possibilities for structural strength and fireproof qualities, this warehouse meets every expectation and requirement. It is remarkable that the drying out was rapid and thorough, and its construction and occupancy in so short a period is in every way favorable to this form of construction.

The offices, which are on the fourth floor, are among the most complete and spacious possessed by any firm in the Northwest. They are approached from the street by a broad stairway lined with fine Tennessee marble and finished in oak trimming, the walls being appropriately frescoed. Vaults 28 x 16 ft. are provided in the offices, the doors of which were made and installed by the Diebold Safe Co. The entire building is equipped with a complete system of pneumatic tubes which distribute orders and correspondence to every department. This is operated by a 7½-h.-p., motor-driven compressor and was put in by the Lamson Consolidated Store Service Co., of Chicago.



View of Utica Power Plant Taken Sept. 5, Showing High Water in Foreground.

Health Conditions in Panama.

Panama Health Conditions remain satisfactory. According to the latest report of Col. Gorgas, chief sanitary officer of the Canal Zone, the sick rate during February was 20 for each thousand of the 23,000 canal employes. In his opinion, this is an excellent state of health. There were 56 deaths among canal employes, and of these 49 were negroes. The annual death rate among employes is 30 to each 1,000 persons. The number of deaths among residents of Panama, Colon and the Canal Zone, exclusive of canal employes, was 176. The number of persons included in this class is 49,951, and consequently the death rate among non-employes was 42 in 1,000. Pneumonia and malarial fever were the chief causes of death, and there was no yellow fever on the isthmus, in spite of its presence in Pacific ports south of Panama and in Caribbean ports, both north and south of Colon.

Coke Oven Gas was used at a British colliery about two years ago in firing a pair of Lancashire boilers. According to statements by Mr. W. C. Blackett at a meeting of the Institution of Mining Engineers, 145 lb. of water were evaporated per pound of coal coked and 5.4 lb. per square foot of heating surface. The temperature of the chimney gases was very high, 750°, and a pair of Babcock & Wilcox boilers were substituted in order to utilize the heat more completely. With them the evaporation was 2.17 lb. of water per pound of coal carbonized, and the temperature of the chimney gases was reduced to 381° Fahr.

The Specific Heat of Superheated Steam.

An interesting discussion of recent investigations of superheated steam has been contributed to the "Rose Technic" by Prof. Frank C. Wagner, of the Rose Polytechnic Institute, in which he gives some new information concerning experiments previously reported in various publications. The information relates mainly to the experiments to determine the specific heat of superheated steam, beginning with those of Mr. J. H. Grindley made something over six years ago. His method was to allow saturated steam at a high pressure, from which the moisture had been removed by passing it through a separator, to expand to a lower pressure through an orifice. He took special care to prevent radiation losses by surrounding the chamber into which the steam expanded by a steam jacket filled with steam at the same temperature. A set of experiments was made in which all started with the same initial temperature but expanded into different lower pressures. Thus the total energy per pound of steam was always the same, since the steam started in the same initial condition and no external work was done other than that which is aways done in the generation of steam at constant pressure, and which is included in the values of the total heat given in the steam tables. Similar series of experiments were made, starting at different initial pressures. Prof. Wagner criticises these experiments because small amounts of moisture were apparently present, and because the thermocouple for measuring the temperature of the steam was too close to the orifice.

A somewhat similar method was used by Griessmann. The steam, instead of being throttled by an orifice, was forced through a plug of silk fibres. The work thus done in overcoming friction was picked up again by the steam, so that the only external work done was that involved in the generation of the steam at constant pressure. This method is held by Prof. Wagner to be preferable to that of Grindley. Greissmann was also successful in removing the moisture from the saturated steam before expanding. Griessmann, like Grindley, regarded the variation in the specific heat as due to the temperature. A study of his experiments indicates to Prof. Wagner that the range of temperatures employed by him was too narrow to show with any certainty how the specific heat varied with the temperature. His experiments do show, however, a regular variation of the specific heat with the pressure. Prof. Wagner has averaged the results and converted them into English units in Table 1.

TABLE 1.—SPECIFIC HEAT AT CONSTANT PRESSURE, GRIESSMANN.

Pressure, Abs.	Spec. Heat.	Av. Temp.
14.22 lb. per sq. in.	.513	284.4° Fahr.
21.33 “	.524	288.4° “
28.44 “	.534	292.0° “
35.55 “	.541	295.6° “
42.66 “	.548	299.1° “
49.77 “	.561	305.0° “
56.88 “	.575	309.6° “
63.99 “	.585	314.4° “
71.10 “	.596	318.7° “
78.21 “	.600	323.6° “
85.32 “	.600	326.5° “

Experiments made by Prof. C. R. Jones in 1900 were performed by measuring the heat required to be removed in order to cool a measured weight of superheated steam about 10° Cent. at constant pressure. His results are given in Table 2.

TABLE 2.—SPECIFIC HEAT AT CONSTANT PRESSURE, JONES.

Pres., Abs.	Spec. Heat	Curve	Diff.
14.51 lb.	.493 Exp.	.484	+.009
34.51 “	.514 “	.514	.000
53.87 “	.541 “	.543	—.002
73.40 “	.568 “	.573	—.005
93.52 “	.608 “	.604	+.004
113.29 “	.632 “	.634	—.002

It will be noticed that both experimental results and those obtained from a "curve" are given. The curve is a straight line having the equation $c = 0.462 + 0.001525\ p$. The temperature of the entering steam averaged about 190° Cent. and of the outgoing steam about 180° Cent., so that the temperature for which the specific heat was determined was substantially 185° Cent. in all the experiments.

These results agree very fairly with those of Griessmann, showing a steady increase in the value of the specific heat as the pressure increases. The values at corresponding pressures are smaller than Griessmann's, which is in entire agreement with Lorenz's experiments about to be referred to. Lorenz found that the specific heat diminished as the temperature increased, the pressures being the same. The average temperature in Griessman's experiment as given above was 305.2° Fahr., or 151.5° C., as compared with 185° C. in Prof. Jones' experiments.

A direct method of determining the specific heat of superheated steam was used also by H. Lorenz. He superheated the steam by a gas furnace and then passed it through a water calorimeter at constant pressure. The steam used was condensed and weighed. The temperatures of the cooling water before and after passing through the calorimeter, as well as the quantity of cooling water, were determined. After making proper corrections for radiation losses the value of the specific heat at the measured constant pressure is readily calculated. The values obtained are given in Table 3:

TABLE 3.—SPECIFIC HEAT, LORENZ.

Abs. Pres	Ave. Temp.	Spec. Heat.
27.5 lb.	405.6° F.	.531
26.9 “	561.2 “	.492
61.3 “	401.7 “	.583
57.6 “	563. “	.484
56.0 “	642. “	.478
97.0 “	405.6 “	.622
97.0 “	534.7 “	.568
98.8 “	609.8 “	.555
127.6 “	432.2 “	.698
127.7 “	503.6 “	.640
127.8 “	596.8 “	.570

In these experiments both the temperature range and the pressure range were considerable, and there is no room for doubt that the specific heat varies with both the pressure and the temperature. It increases with increasing pressure and diminishes with increasing temperature.

The problem has been attacked from a still different standpoint by R. Linde. Making use of a new and careful determination of the specific volume of superheated steam at various pressures and temperatures, Linde has constructed an equation for superheated steam, and by the general well-known equation for specific heat at constant pressure he calculates the values of the variable part of the specific heat. Assuming that the constant term in the specific heat is such as to give Regnault's value of .480 at atmospheric pressure he calculated the specific heat at constant pressure to be as given in Table 4:

TABLE 4.—SPECIFIC HEAT, LINDE.

Pressure.	Temperature.	Spec. Heat.
14.2 lb.	288° F.	.483
28.4 “	292 “	.500
42.7 “	299 “	.515
56.9 “	310 “	.528
71.1 “	319 “	.541
85.3 “	328 “	.556

This also shows that the specific heat of superheated steam increases with the pressure and the form of the equation used by Linde shows that the specific heat also decreases with the temperature when the pressure is constant. The equation proposed by Linde to represent the relation between the pressure, volume and temperature of superheated steam is:

$$pv = BT - p\,(1 + ap)\left[C\left(\frac{373}{T}\right)^3 - D\right]$$

where $B = 47.1$; $a = .000002$; $C = .0310$; $D = .0052$. By introducing the equation for the adiabatic of superheated steam he deduces for the value of the specific heat of steam at constant pressure:

$$c_p = An\left[B + 3p\,(1 + ap)\ \frac{C}{T}\left(\frac{373}{T}\right)^3\right]$$

A is the reciprocal of the mechanical equivalent of a calorie in kilogrammetres; $n = 4.2$; p is the pressure in kilograms per square centimetre; and T is the absolute temperature in degrees Centigrade.

Using this equation of Linde Prof. Wagner calculated the values of c_p for a temperature of 392° and also for a constant temperature of 572° F., with the results given in Table 5:

TABLE 5.—VALUES OF c FOR TEMPERATURES OF 392° AND 527° F.

Abs. Pres.	392°	572°
14.22 lb.	0.477	0.472
28.44 “	0.487	0.476
42.66 “	0.497	0.481
56.88 “	0.508	0.486
71.10 “	0.520	0.491
85.32 “	0.531	0.496
99.54 “	0.543	0.501
113.76 “	0.556	0.507

A few months ago Prof. O. Knoblauch published a note concerning experiments to determine the specific heat of superheated steam, which were made in a quite different manner from any previously employed. The steam under pressure from the boiler was first passed through a series of chambers containing electrical heating coils where it could be superheated to any desired amount. A portion of this superheated steam was then passed through a copper coil immersed in an oil bath and still further superheated, after which it was condensed and weighed. The temperatures of the superheated steam, both before and after passing through the copper coil and the amount of electrical energy absorbed by the steam were determined and from these the specific heat was calculated. The energy absorbed by the steam in the copper coil was determined by finding the difference between the electrical energy required when the steam was passing and that required to maintain the oil bath at the same temperature when the steam was shut off. The numerical results have not been given, but it was reported that the tests were made at pressures of 2, 4, 6 and 8 atmospheres and at intervals of 50° up to 350° Cent.; the values thus obtained are stated to agree within 3 per cent. with those calculated by the Linde formula.

Prof. Wagner has plotted the values of c in terms of the pressure for each set of experiments where the temperature was substantially constant. The results obtained by Griessmann and Jones agree very satisfactorily, and the results obtained by Lorenz show substantial agreement with the others, but are more erratic. The values calculated by Linde's equation agree fairly well with the curves given at low pressures in some instances, but at higher pressures the calculated values are smaller than those obtained experimentally. As a result of his study, Prof. Wagner is convinced that further experiments are needed, particularly at high pressures and temperatures, to settle definitely the values of the specific heat of superheated steam under the conditions now frequently met in commercial practice.

THE AMERICAN CEMENT INDUSTRY in 1905 produced 40,894,308 bbl. of Portland, natural and slag grades, worth $36,012,189, according to the U. S. Geological Survey. This was an increase of 9,219,051 bbl., valued at $9,980,269, over the production of the previous year. Of the total amount 36,038,812 bbl. were Portland cement, with a value of $33,326,523; 4,473,049 bbl. were natural rock cement, valued at $2,413,052, and 382,447 bbl. were slag cement, valued at $272,614.

Book Notes.

In the notices of new books in this journal on Sept. 23, 1905, mention was made of a volume by Mr. Wilhelm Gantsch in which the subject of steam turbines was treated in an unusual manner. This book has been translated by Mr. Arthur R. Liddell and published at $6 by Longmans, Green & Co., New York, the English title being "Steam Turbines, Their Development, Styles of Build, Construction and Uses." Its main characteristic is a great mass of data, mainly prepared from patent specifications, covering the development of these prime-movers. As a reference manual to explain what has been attempted with steam turbines, unsuccessfully as well as successfully, the book has a unique value. Another important feature, which was mentioned in the notice of the original German text, is a new classification of turbines into velocity and pressure types. The text is not so technical as that of the works of Stodola, Eyermann or Thomas, which it supplements; in fact it is essentially a description of designs for turbines and the general principles on which they are based, rather than an explanation in detail of any of the laws of steam flow or the like. The translation has been well done and as the original German text was highly commended in the review of it, there is no call for further notice of the English edition.

Prof. Hans Lorenz, of Gottingen, is so well known as an authority on refrigeration that his "Modern Refrigerating Machinery," which has just appeared in an English translation by Mr. Thomas H. Pope, is certain to meet a warm reception in this country, where it is published at $4 by John Wiley & Sons, New York. Although the author has achieved his high reputation as a specialist mainly through theoretical investigations, the book is eminently practical and intended for the use of men in charge of refrigerating plants. It opens with an explanation of some of the fundamental principles of heat, which is followed by an explanation of the different practicable methods of securing low temperatures. The details of the plant for refrigerating purposes are then taken up, beginning with compressors, of which only European horizontal double-acting types are described. Condensers, cooling towers, evaporators, coolers and brine tanks are explained, in some cases in considerable detail. The absorption system of refrigeration is next described and its operation is outlined. In the following three chapters the use of refrigerating machinery for cooling liquids, air and gases and for ice making is explained from the standpoint of European methods, which are not always in harmony with those followed in this country. The methods of securing very low temperatures are explained at considerable length, but as these are not considered in commercial refrigeration this portion of the book might as well be omitted. In a final chapter the efficiency of cooling machinery is discussed and there are some very sound suggestions concerning specifications for such apparatus and tests to see that the requirements are satisfied. The book is essentially a reflection of the best European practice and the American publishers have accordingly secured for their edition of it an appendix by Messrs. Henry M. Haven and F. W. Dean describing American practice. This relates mainly to the methods employed in the North, where the apparatus and its arrangement are different from those generally employed in the South. On this account the appendix ought to be materially enlarged, because as it now stands it hardly does justice to machinery and methods giving satisfaction throughout a considerable territory, particularly in small plants.

Letters to the Editor.

Problems in Railway Curves.

Sir: The following solution of the problem presented by Mr. Wm. R. Dunham, Jr., in your issue of April 7 is submitted: Given d, r, R and the angle A, Fig. 1, it is required to find the angle X. In the right triangle, $O'ST$, $O'T = R - r$, and the angle A is known, hence TS can be computed. $SB = R - TS$. $HP = d' = SB - d$ when $R - TS$ is greater than d. When $R - TS$ is less than d, $HP = d - SB$. $PO = r + HP$ when $R - TS$ is greater than d; when $R - TS$ is less than d, $PO = r - HP$. In the triangle LOO', $LO = R - r$, $LO' = R + r$ and the angle A is given, from which data the side OO' and the angle LOO' can be calculated. In the right triangle OPO', the sides PO and OO' having been determined, the angle POO' can be calculated. The required angle X is equal to the angle $POO' - (180° - LOO')$.

Yours very truly, Emil L. Nuebling.
Reading, Pa., April 11.

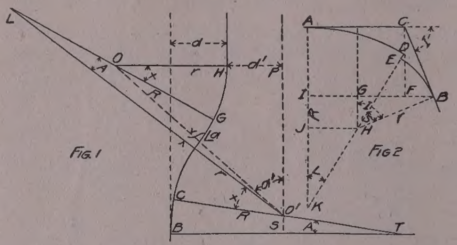
Sir: The problem submitted by Mr. Wm. R. Dunham, Jr., in your issue of April 7 may be solved as follows: Determine an angle B and an angle $(B + X)$ so that

$$tan\ B = \frac{(R+r)\ sin\ A}{(R+r)\ cos\ A - (R-r)}$$

$$cos(B+X) = \frac{[(R+r) - (R-r)\ cos\ A - d]\ sin\ B}{(R+r)\ sin\ A}$$

Then the difference of these two angles equals the angle X.

Yours respectfully, Benj. G. Love.
Philadelphia, April 10.



Railway Curve Diagrams.

Sir: Enclosed is a solution of the reversed curve problem in your issue of April 7. In Fig. 1 the distance d is made up of four quantities, viz.: R vers. A, r vers. $(A + X) - r$ vers. A, R vers. $(A + X) - R$ vers. X, and r vers. X. If we set the sum of these quantities equal to d, using $1 - cos$ for versed sine and remembering that $cos\ (A + X) = cos\ A\ cos\ X - sin\ A\ sin\ X$, the equation reduces to the form $cos\ X + n\ sin\ X = k$, in which n and k are known quantities. The equation may then be solved for X.

Respectfully, R. E. Porter.
Toledo, April 11.

Sir: I beg to submit the following solution of Mr. Dunham's problem in your issue of April 7. Given the two equal long radii, the two equal short radii, d, and the angle A, Fig. 1, to find X. In the triangle LOO', having LO, LO' and the angle A, compute OO' and a. The angle $GOO' = A + a$. In the right triangle POO', the angle at O and the side OO' are known, so that d' and a' can be computed. Then $X = 90° - (A + a + a')$.

Very respectfully, H. L. Smith.
New York.

Sir: It gives me pleasure to submit the following solution of the problem in railway curves in your issue of March 24: In Fig. 2 AK represents the larger radius, R, and HB the smaller radius, r. AC and BC are the apex distances. All these are known, together with the intersection angle at C. The problem is to determine the offset distance, $ED = O$ and the angles AKD and DHB.

Assume AK to be the north and south line and work the figure $KACBHK$ out by traverse, letting the distances and angles be lengths and bearings. They may be put down thus:

Course.	Length.	Bearing.	N.Lat.	S.Lat.	E.Dep.	W.Dep.
AK	known	known	....	....	....	....
AC	"	"	....	....	....	....
CB	"	"	....	....	....	....
BH	"	"	....	....	....	....
HK	sought	sought	....	....	....	....

Computing this traverse we obtain the length and bearing of HK, which determines the angle AKD and BHD, or the center angles of the two curves. Then $R - r - KH = O$, the perpendicular offset required.

Very truly,
Daniel D. Stiltz.
Oroville, Cal., April 8.

The Removal of Crank Case Oil by Separators.

Sir: We were much interested in reading the description of the Pennsylvania R. R. Company's Long Island City power station which appeared in your issue of April 7. There is in this article, however, one point to which we take serious exception. Beginning at the tenth line in the second column on page 457, we quote as follows: "The Westinghouse single-acting engines driving auxiliary machinery do not send their exhaust steam to this heater on account of particles of crank case oil that may work into the exhaust."

While the engineers of this plant may not believe that the crank case oil can be removed from the exhaust steam by an oil separator, and while it may be true that many makes of oil separators are not efficient enough to remove this oil, it is a positive fact that the Cochrane oil separators, when installed to meet these conditions, will remove this oil. The exhaust steam from the Westinghouse single-acting engine in our own plant has for years been passed through a Cochrane oil separator into a Cochrane feed-water heater from which our boilers are fed, and we have absolutely no trouble from oil in the boilers. We could give you the names of a number of other plants in which our Cochrane oil separators give thoroughly successful and satisfactory service in taking the oil out of exhaust steam from Westinghouse engines.

Harrison Safety Boiler Works.
Philadelphia, April 14.

Setting Out Curves in Streets.

Sir: A correspondent in your issue of March 31 states that no curve can be run on the ground by setting stakes, "because it cannot be done." A very simple way is to set stakes at frequent intervals, say 10 ft. apart, and make a wooden templet with the proper curve, and set it against the stakes. If your correspondent cares to go to a stone quarry he will see that this is the method used to cut curved curb stone, and they are surely not a series of straight lines. A stone monument in the sidewalk, if properly set, would not give trouble by coming up, and if not permanently set would be of no value as a monument. Naturally, the monument should be set flush with the sidewalk, and have a hole in the center or a cross cut in the top, either of which would be accurate and easily found.

Yours truly,
G. Haselton.
Portland, Ore.